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SOLVED PAPER

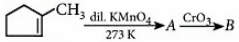
Held on
24th Feb, Morning Shift

JEE MAIN 2021

SECTION A (MULTIPLE CHOICE QUESTIONS)

1. Out of the following, which type of interaction is responsible for the stabilisation of α-helix structure of proteins?
   (a) Ionic bonding (b) van der Waals forces
   (c) Hydrogen bonding (d) Covalent bonding

2. Identify products *A* and *B*.



   (a) *A* :  *B* : 

   (b) *A* :  *B* : 

   (c) *A* :  *B* : 

   (d) *A* : $OHC-CH_2CH_2CH_2-\overset{O}{\overset{\|}{C}}-CH_3$

   B : $HOOC-CH_2CH_2CH_2-\overset{O}{\overset{\|}{C}}-CH_3$

3. Which of the following are isostructural pairs?
   A. SO_4^{2-} and CrO_4^{2-}
   B. $SiCl_4$ and $TiCl_4$
   C. NH_3 and NO_3^-
   D. BCl_3 and $BrCl_3$
   (a) C and D only (b) B and C only
   (c) A and C only (d) A and B only

4. Given below are two statements :
   Statement I : Colourless cupric metaborate is reduced to cuprous metaborate in a luminous flame.
   Statement II : Cuprous metaborate is obtained by heating boric anhydride and copper sulphate in a non-luminous flame.
   In the light of the above statements, choose the most appropriate answer from the options given below :
   (a) Statement I is false but Statement II is true.
   (b) Both Statement I and Statement II are true.
   (c) Both Statement I and Statement II are false.
   (d) Statement I is true but Statement II is false.

5. Match List-I with List-II.

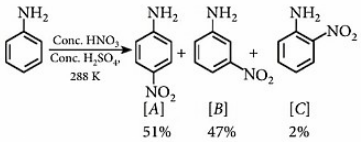
List-I (Monomer Unit)		List-II (Polymer)	
(A)	Caprolactum	(i)	Natural rubber
(B)	2-Chloro-1,3-butadiene	(ii)	Buna-N
(C)	Isoprene	(iii)	Nylon 6
(D)	Acrylonitrile	(iv)	Neoprene

   Choose the correct answer from the options given below :
   (a) (A)-(iv), (B)-(iii), (C)-(ii), (D)-(i)
   (b) (A)-(ii), (B)-(i), (C)-(iv), (D)-(iii)
   (c) (A)-(i), (B)-(ii), (C)-(iii), (D)-(iv)
   (d) (A)-(iii), (B)-(iv), (C)-(i), (D)-(ii)

6. Which of the following ore is concentrated using group 1 cyanide salt?
   (a) Sphalerite (b) Malachite
   (c) Calamine (d) Siderite

7. The major components in "Gun Metal" are :
   (a) Cu, Zn and Ni (b) Cu, Ni and Fe
   (c) Cu, Sn and Zn (d) Al, Cu, Mg and Mn

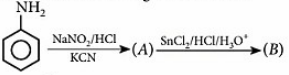
8. In the following reaction the reason why *meta*-nitro product also formed is :



(a) $-NH_2$ group is highly *meta*-directive
(b) low temperature
(c) $-NO_2$ substitution always takes place at *meta*-position
(d) formation of anilinium ion.

9. Consider the elements Mg, Al, S, P and Si, the correct increasing order of their first ionization enthalpy is :
(a) Al < Mg < S < Si < P (b) Mg < Al < Si < S < P
(c) Al < Mg < Si < S < P (d) Mg < Al < Si < P < S

10. '*A*' and '*B*' in the following reactions are :

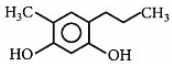
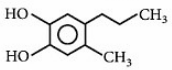
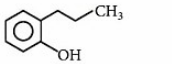
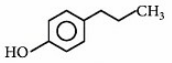


(a) (*A*):  (*B*): 
(b) (*A*):  (*B*): 
(c) (*A*):  (*B*): 
(d) (*A*):  (*B*): 

11. The electrode potential of M^{2+}/M of 3*d*-series elements shows positive value for
(a) Co (b) Zn (c) Cu (d) Fe

12. The gas released during anaerobic degradation of vegetation may lead to
(a) corrosion of metals (b) acid rain
(c) ozone hole
(d) global warming and cancer.

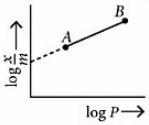
13. Which of the following compound gives pink colour on reaction with phthalic anhydride in conc. H_2SO_4 followed by treatment with NaOH?

(a) 
(b) 
(c) 
(d) 

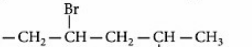
14. Which of the following reagent is used for the following reaction?
$CH_3CH_2CH_3 \xrightarrow{?} CH_3CH_2CHO$
(a) Copper at high temperature and pressure
(b) Molybdenum oxide
(c) Potassium permanganate
(d) Manganese acetate

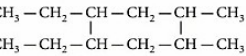
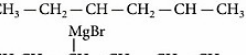
15. Al_2O_3 was leached with alkali to get *X*. The solution of *X* on passing of gas *Y*, forms *Z*. *X*, *Y* and *Z* respectively are
(a) $X = Al(OH)_3$, $Y = SO_2$, $Z = Al_2O_3.xH_2O$
(b) $X = Na[Al(OH)_4]$, $Y = SO_2$, $Z = Al_2O_3$
(c) $X = Na[Al(OH)_4]$, $Y = CO_2$, $Z = Al_2O_3.xH_2O$
(d) $X = Al(OH)_3$, $Y = CO_2$, $Z = Al_2O_3$

16. In Freundlich adsorption isotherm, slope of *AB* line is
(a) $\log \frac{1}{n}$ with $(n < 1)$
(b) $\frac{1}{n}$ with $\left(\frac{1}{n} = 0 \text{ to } 1\right)$
(c) $\log n$ with $(n > 1)$
(d) n with $(n, 0.1 \text{ to } 0.5)$



17. The product formed in the first step of the reaction of



with excess $Mg/Et_2O(Et = C_2H_5)$ is
(a) 
(b) 

(c) $CH_3-CH_2-\underset{\displaystyle CH_3-CH-CH_2-CH-CH_2-CH_3}{\underset{|}{CH}}-CH_2-\underset{|}{CH}-CH_3$

(d) $CH_3-CH\begin{cases}CH_2\\ |\\ CH-CH_3\end{cases}$

18. (*A*) $HOCl + H_2O_2 \rightarrow H_3O^+ + Cl^- + O_2$

(*B*) $I_2 + H_2O_2 + 2OH^- \rightarrow 2I^- + 2H_2O + O_2$

Choose the correct option.

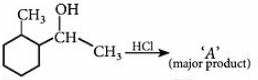
(a) H_2O_2 acts as reducing and oxidising agent respectively in equations (*A*) and (*B*).

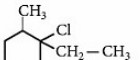
(b) H_2O_2 acts as reducing agent in equations (*A*) and (*B*).

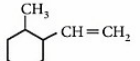
(c) H_2O_2 acts as oxidising agent in equations (*A*) and (*B*).

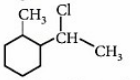
(d) H_2O_2 acts as oxidizing and reducing agent respectively in equations (*A*) and (*B*).

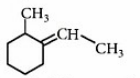
19. What is the final product (major) '*A*' in the given reaction?



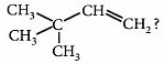
(a) 

(b) 

(c) 

(d) 

20. What is the major product formed by HI on reaction with



(a) $CH_3-\underset{\displaystyle CH_3\ I}{\underset{|}{C}}-\underset{|}{CH}-CH_3$ (CH3 on C)

(b) $CH_3-\underset{\displaystyle CH_3\ H}{\underset{|}{C}}-\underset{|}{CH}-CH_2I$ (CH3 on C)

(c) $CH_3-\underset{\displaystyle I\ \ CH_3}{\underset{|}{C}}-\underset{|}{CH}-CH_3$ (CH3 on C)

(d) $CH_3-\underset{\displaystyle CH_3}{\underset{|}{CH}}-\underset{|}{CH}-CH_2-CH_3$ (I on CH)

SECTION B (NUMERICAL VALUE TYPE)

Attempt any 5 questions out of 10.

21. Gaseous cyclobutene isomerizes to butadiene in a first order process which has a '*k*' value of $3.3 \times 10^{-4}\ s^{-1}$ at 153 °C. The time in minutes it takes for the isomerization to proceed 40% to completion at this temperature is _____.
(Rounded off to the nearest integer)

22. The reaction of sulphur in alkaline medium is given below

$S_{8(s)} + a\ OH^-_{(aq)} \longrightarrow b\ S^{2-}_{(aq)} + c\ S_2O_3^{2-}{}_{(aq)} + d\ H_2O_{(l)}$

The value of '*a*' is _____. (Integer answer)

23. The stepwise formation of $[Cu(NH_3)_4]^{2+}$ is given below

$Cu^{2+} + NH_3 \overset{K_1}{\rightleftharpoons} [Cu(NH_3)]^{2+}$

$[Cu(NH_3)]^{2+} + NH_3 \overset{K_2}{\rightleftharpoons} [Cu(NH_3)_2]^{2+}$

$[Cu(NH_3)_2]^{2+} + NH_3 \overset{K_3}{\rightleftharpoons} [Cu(NH_3)_3]^{2+}$

$[Cu(NH_3)_3]^{2+} + NH_3 \overset{K_4}{\rightleftharpoons} [Cu(NH_3)_4]^{2+}$

The value of stability constants K_1, K_2, K_3 and K_4 are 10^4, 1.58×10^3, 5×10^2 and 10^2 respectively. The overall equilibrium constant for dissociation of $[Cu(NH_3)_4]^{2+}$ is $x \times 10^{-12}$. The value of x is _____.
(Rounded off to the nearest integer)

24. The coordination number of an atom in a body-centered cubic structure is _____.
[Assume that the lattice is made up of atoms.]

25. At 1990 K and 1 atm pressure, there are equal number of Cl_2 molecules and Cl atoms in the reaction mixture. The value of K_P for the reaction $Cl_{2(g)} \rightleftharpoons 2Cl_{(g)}$ under the above conditions is $x \times 10^{-1}$. The value of x is _____. (Rounded off to the nearest integer)

26. 4.5 g of compound *A* ($MW = 90$) was used to make 250 mL of its aqueous solution. The molarity of the solution in *M* is $x \times 10^{-1}$. The value of x is _____.
(Rounded off to the nearest integer)

27. When 9.45 g of $ClCH_2COOH$ is added to 500 mL of water, its freezing point drops by 0.5°C. The dissociation constant of $ClCH_2COOH$ is $x \times 10^{-3}$. The value of x is _____.
(Rounded off to the nearest integer)
[$K_{f(H_2O)} = 1.86\ K\ kg\ mol^{-1}$]

28. For the reaction $A_{(g)} \rightarrow B_{(g)}$, the value of the equilibrium constant at 300 K and 1 atm is equal to 100.0. The value of $\Delta_r G$ for the reaction at 300 K and 1 atm in $J\ mol^{-1}$ is $-xR$ where x is _____.
(Rounded off to the nearest integer)
[$R = 8.31\ J\ mol^{-1}\ K^{-1}$ and $\ln 10 = 2.3$]

29. Number of amphoteric compounds among the following is _____.

(A) BeO (B) BaO

(C) $Be(OH)_2$ (D) $Sr(OH)_2$

30. A proton and a Li^{3+} nucleus are accelerated by the same potential. If λ_{Li} and λ_p denote the de Broglie wavelengths of Li^{3+} and proton respectively, then the value of $\frac{\lambda_{Li}}{\lambda_p}$ is $x \times 10^{-1}$. The value of x is _____.

(Rounded off to the nearest integer)

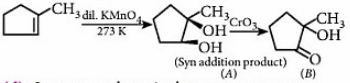
[Mass of Li^{3+} = 8.3 mass of proton]

SOLUTIONS

1. **(c) :** The α-helix structure of proteins is stabilized by hydrogen bonds between the NH and CO groups of the main chain.

2. **(c) :** Alkenes get converted into *cis*-diols on reaction with $KMnO_4$ solution by syn-dihydroxylation. Further CrO_3 oxidises primary alcohols to aldehydes and secondary alcohols to ketones. It is a mild oxidising agent, hence does not affect tertiary alcohols.

The reactions can be summarized as :



(Syn addition product) (*A*) (*B*)

3. **(d):** Isostructural species have same structures

Ion	Hybridisation	Geometry
SO_4^{2-}	sp^3	Tetrahedral
CrO_4^{2-}	sp^3	Tetrahedral
$SiCl_4$	sp^3	Tetrahedral
$TiCl_4$	sd^3	Tetrahedral
NH_3	sp^3	Pyramidal
NO_3^-	sp^2	Trigonal planar
BCl_3	sp^2	Trigonal planar
$BrCl_3$	sp^3d	*T*-shaped

4. **(c) :** Cupric metaborate is formed by heating boric anhydride with $CuSO_4$ in an oxidising (non-luminous) flame.

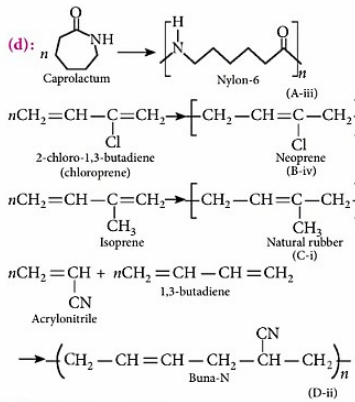
$$B_2O_3 + CuSO_4 \xrightarrow[\text{flame}]{\text{Oxidising}} \underset{\text{(Cupric metaborate)}}{Cu(BO_2)_2} + SO_3$$

(Blue-green)

Blue cupric metaborate is reduced to colourless cuprous metaborate in reducing (luminous) flame.

$$\underset{\text{(Blue)}}{2Cu(BO_2)_2} + 2NaBO_2 + C \xrightarrow[\text{flame}]{\text{Reducing}} \underset{\text{(Colourless)}}{2CuBO_2} + Na_2B_4O_7 + CO$$

5. **(d):**



6. **(a) :** Sphalerite : ZnS

Malachite : $CuCO_3 \cdot Cu(OH)_2$

Calamine : $ZnCO_3$

Siderite : $FeCO_3$

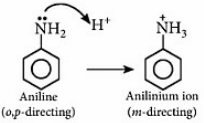
Sphalerite can be dissolved in 1st group cyanide salt *i.e.*, NaCN, KCN.

NaCN reacts with ZnS to form a complex.

$$4NaCN + ZnS \longrightarrow \underset{\text{Soluble complex}}{Na_2[Zn(CN)_4]} + Na_2S$$

7. **(c) :** Gun metal also known as red brass is a type of bronze and consists of copper, tin and zinc.

8. **(d):** Due to the presence of acid in the reaction mixture $-\ddot{N}H_2$ gets converted to $-\overset{+}{N}H_3$ as $-NH_2$ contains lone pair of electron which can be easily donated.

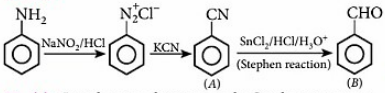


Aniline (*o,p*-directing) Anilinium ion (*m*-directing)

9. **(c) :** Ionisation enthalpy generally increases from left to right in a period due to increase in effective nuclear charge. But *I.E.* (S) < *I.E.* (P) due to the extra stability of half-filled electronic configuration of (P) and *I.E.* (Al) < *I.E.* (Mg) due to the extra stability of fully filled electronic configuration of Mg.

Hence, the correct order of *I.E.* is Al < Mg < Si < S < P

10. (b):



11. (c): In 3*d* series elements, only Cu shows positive value for electrode potential of M^{2+}/M.

$Co^{2+}/Co = -0.28$ V

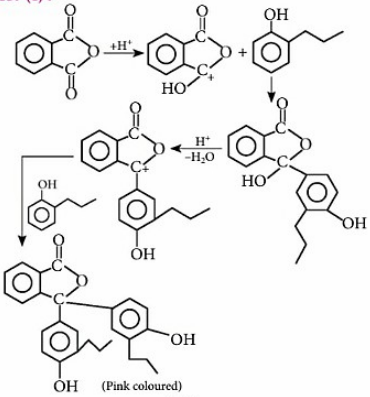
$Zn^{2+}/Zn = -0.76$ V

$Cu^{2+}/Cu = +0.34$ V

$Fe^{2+}/Fe = -0.44$ V

12. (d): During anaerobic degradation when microorganisms break down the organic material in the absence of air (or oxygen) the gases released are methane, carbon dioxide with very small amounts of water vapour and other gases. CO_2 and CH_4 gases are responsible for global warming and cancer.

13. (c):



14. (b): $CH_3CH_2CH_3 \xrightarrow{MoO_3} CH_3CH_2CHO$

15. (c):

$$Al_2O_{3(s)} + 2NaOH_{(aq)} + 3H_2O_{(l)} \rightarrow \underset{X}{2Na[Al(OH)_4]_{aq}}$$

$$\xrightarrow{CO_{2(g)}} \underset{Y}{} \rightarrow \underset{Z}{Al_2O_3 \cdot xH_2O_{(s)}} + 2NaHCO_{3(aq)}$$

16. (b): According to Freundlich adsorption isotherm,

$$\frac{x}{m} = kP^{1/n}$$

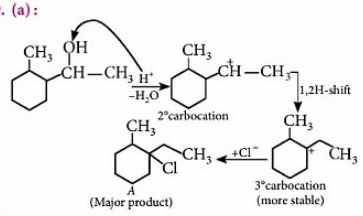
$$\log\frac{x}{m} = \log k + \frac{1}{n}\log P$$

Hence, slope is $\frac{1}{n}$ with $\left(\frac{1}{n} = 0 \text{ to } 1\right)$; $0 \le \frac{1}{n} \le 1$

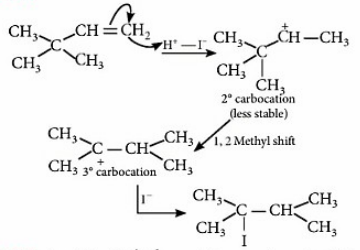
17. (b):

18. (b): In reaction (*A*) reduction of HOCl occurs and in reaction (*B*) reduction of I_2 occurs hence H_2O_2 is acting as a reducing agent in both the given equations.

19. (a):



20. (c):



21. (26): $k = 3.3 \times 10^{-4}\ s^{-1}$, $x = 0.4$ $\quad (a - x) = 0.6$

$$k = \frac{2.303}{t}\log\frac{a}{a-x}$$

$$t = \frac{2.303}{3.3\times10^{-4}}\log\frac{1}{0.6} = 1554 \text{ s}$$

$$t = \frac{1554}{60} = 25.9 \text{ or } 26 \text{ minutes}$$

Monthly Test Drive CLASS XII ANSWER KEY

1.	(b)	**2.**	(a)	**3.**	(a)	**4.**	(a)	**5.**	(c)
6.	(d)	**7.**	(c)	**8.**	(c)	**9.**	(d)	**10.**	(a)
11.	(c)	**12.**	(d)	**13.**	(c)	**14.**	(c)	**15.**	(c)
16.	(b)	**17.**	(c)	**18.**	(b)	**19.**	(b)	**20.**	(b,c)
21.	(c,d)	**22.**	(a,c,d)	**23.**	(a,c)	**24.**	(4)	**25.**	(3)
26.	(1)	**27.**	(d)	**28.**	(b)	**29.**	(b)	**30.**	(d)

22. (12) : Balanced equation can be written as

$S_8 + 12OH^- \longrightarrow 4S^{2-} + 2S_2O_3^{2-} + 6H_2O$

The value of a is 12.

23. (1) : Equilibrium constant for the overall reaction

$Cu^{2+} + 4NH_3 \rightleftharpoons [Cu(NH_3)_4]^{2+}$

can be given as $K = K_1 \times K_2 \times K_3 \times K_4$

$K = 10^4 \times 1.58 \times 10^3 \times 5 \times 10^2 \times 10^2$

$= 7.9 \times 10^{11}$

For dissociation of $[Cu(NH_3)_4]^{2+}$,

Equilibrium constant $K' = \frac{1}{K} = \frac{1}{7.9 \times 10^{11}} = 1.26 \times 10^{-12}$

Hence, $x = 1$ (rounded off to the nearest integer)

24. (8) : Coordination number of an atom in a body centered cubic structure (*bcc*) is 8.

25. (5) : $T = 1990$ K ; $P = 1$ atm

$Cl_2 \rightleftharpoons 2Cl$

Moles of Cl_2 = Moles of Cl = x

Total moles = $2x$

$p_{Cl_2} = \frac{x}{2x} \times 1 = \frac{1}{2}$; $p_{Cl} = \frac{x}{2x} \times 1 = \frac{1}{2}$

$K_P = \frac{(p_{Cl})^2}{p_{Cl_2}} = \frac{\frac{1}{2} \times \frac{1}{2}}{\frac{1}{2}} = \frac{1}{2} = 0.5 = 5 \times 10^{-1}$

The value of x is 5.

26. (2) : Mass of compound A = 4.5

Molar mass = 90

V = 250 mL

$\text{Molarity} = \frac{\text{Moles of compound } A}{V(\text{mL})} \times 1000$

$= \frac{4.5/90}{250} \times 1000 = \frac{1000}{20 \times 250}$

$= \frac{4}{20} = \frac{1}{5} = 0.2$ mol/L or 2×10^{-1} M

So, the value of x is 2.

27. (35) : $\Delta T_f = 0.5°C$; $V = 500$ mL

$K_f = 1.86$ K kg mol^{-1}

Mass of compound = 9.45 g

$M = 35.5 + 24 + 3 + 32 = 94.5$

$m = \frac{9.45}{94.5} \times \frac{1000}{500} = 0.2$ [density of water ≈ 1g/mL]

$\Delta T_f = i\, k_f\, m$

$0.5 = i \times 0.2 \times 1.86$

$i = \frac{0.5}{0.2 \times 1.86} = 1.34$

$1 + \alpha = 1.34 \quad \Rightarrow \quad \alpha = 0.34$

At equilibrium : $\underset{C-C\alpha}{ClCH_2COOH} \rightleftharpoons \underset{C\alpha}{ClCH_2COO^-} + \underset{C\alpha}{H^+}$

$K_a = \frac{(C\alpha)^2}{(C - C\alpha)} = \frac{C\alpha^2}{1 - \alpha} = \frac{0.2 \times (0.34)^2}{(1 - 0.34)} = 35 \times 10^{-3}$

28. (1380) : $K_{eq.} = 100$, $T = 300$ K $\qquad P = 1$ atm

$\Delta G = -2.3\, RT \log K$

$= -2.3 \times R \times 300 \log 100$

$= -2.3 \times R \times 2 \times 300 = -1380\, R$

29. (2) : BeO — Amphoteric oxide

BaO — Basic oxide

$Be(OH)_2$ — Amphoteric hydroxide

$Sr(OH)_2$ — Basic hydroxide

30. (2) : $\lambda = \frac{h}{\sqrt{2meV}}$

$\lambda_{Li^{3+}} = \frac{h}{\sqrt{2m_{Li^{3+}} eV}}$; $\lambda_p = \frac{h}{\sqrt{2m_p eV}}$

Given, $V_{Li^{3+}} = V_p$

$m_{Li^{3+}} = 8.3 m_p$

$\frac{\lambda_{Li^{3+}}}{\lambda_p} = \frac{\sqrt{m_p(e) \times V}}{\sqrt{8.3 m_p \times 3e \times V}} = \frac{1}{\sqrt{8.3 \times 3}}$

$= \frac{1}{5} = 0.2 = 2 \times 10^{-1}$

unacademy

Time-management and preparation tips for NEET-UG 2021 and NEET-UG 2022

Aashish Bansal

Director & HOD (Chemistry)
Sarvottam Career Institute, Kota
18+ years of experience
Mentored over 20,000+ Learners including NEET-UG AIR 1, AIIMS AIR 2, 3 and 5

This year NEET-UG 2021 will be conducted on August 1, 2021, across the country. This means we have approximately 4 months left for preparation. The ideal way to utilise this time effectively is to allocate two slots of 60 days each for revision.

The first 60 days should be used to revise the theory of the syllabus prescribed and the last 60 days should be dedicated to solving question papers and giving Mock Tests. You can solve questions from various places like NCERT Exemplar Exercises, Question-Banks and Daily-Practice Problems provided by your Educators and of course, Previous Years' Question Papers.

While proper revision is necessary, aspirants must also focus on getting proper sleep, having light food and leading a balanced lifestyle because after all, a sound body keeps a sound mind.

While NEET-UG 2021 is just around the corner, aspirants preparing for NEET-UG 2022 have a lot of time at hand. So in case you are preparing for NEET-UG 2022, you should focus mainly on NCERT content including theory and questions. You can also watch Unacademy's Live and Recorded Classes to get ahead in your preparation.

Last but not the least, I would like to reiterate that a dream does not become reality through magic or wishful thinking. It takes sweat, determination and hard work. So strategise and put your best foot forward.

All the best.

PRACTICE PAPER
NEET 2021

1. In which of the following pairs, both species have similar geometry?
   (a) CH_4, BF_3 (b) NH_3, BH_3
   (c) CO_3^{2-}, SO_3^{2-} (d) SO_4^{2-}, ClO_4^-

2. Most stable free radical is
   (a)  (b) 
   (c)  (d) 

3. The relative ease of dehydration of following alcohols is
   $CH_3CH(OH)CH_3$, $(CH_3)_3COH$, $CH_3CH_2CH_2OH$
   I II III
   (a) I > II > III (b) III > I > II
   (c) III > II > I (d) II > I > III

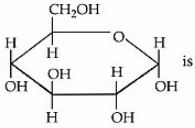
4. An element (with atomic mass = 300) crystallises in a simple cubic. If the density of the unit cell is 9.5 g cm^{-3}, what is the radius of the element?
   (a) 1.87×10^{-8} cm (b) 1.97×10^{-8} cm
   (c) 1.77×10^{-8} cm (d) 1.02×10^{-8} cm

5. Which of the following molecules is the most polar?
   (a) CH_3NH_2 (b) $(CH_3)_3CCl$
   (c) CH_3NO_2 (d) $(CH_3)_3CH$

6. Calculate q and w for the isothermal reversible expansion of one mole of an ideal gas from an initial pressure of 1.0 bar to a final pressure of 0.1 bar at a constant temperature of 273 K.
   (a) 5.227 kJ, –5.227 kJ (b) –5.227 kJ, 5.227 kJ
   (c) 27.31 kJ, –27.31 kJ (d) –27.31 kJ, 27.31 kJ

7. Biochemical Oxygen Demand, (BOD) is a measure of organic material present in water. BOD value less than 5 ppm indicates a water sample to be
   (a) rich in dissolved oxygen
   (b) poor in dissolved oxygen
   (c) highly polluted
   (d) not suitable for aquatic life.

8. In which of the following halides, the halogen atom is attached to sp^3 hybridised carbon atom?
   (a) Allylic halides (b) Vinylic halides
   (c) Benzylic halides (d) Both (a) and (c)

9.  is
   (a) Fischer projection formula of α-*D*-glucose
   (b) Fischer projection formula of β-*D*-glucose
   (c) Haworth projection formula of α-*D*-glucose
   (d) Haworth projection formula of β-*D*-glucose.

10. Reaction of diborane with ammonia gives initially
    (a) borazine (b) borazole
    (c) $B_2H_6.3NH_3$ (d) $[BH_2(NH_3)_2]^+[BH_4]^-$

11. The increasing order of number of atoms present in the following is
    (I) 52 moles of Ar (II) 52 u of He
    (III) 52 g of He
    (a) (I) < (II) < (III) (b) (III) < (II) < (I)
    (c) (II) < (III) < (I) (d) (III) < (I) < (II)

12. Correct arrangement of the following acids in decreasing order of pK_a values is
    CH_3COOH, $Cl_2CHCOOH$, F_3CCOOH,
    I II III

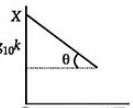
$ClCH_2COOH$, FCH_2COOH
IV V

(a) I > III > II > IV > V
(b) I > IV > V > II > III
(c) III > II > I > V > IV
(d) II > III > I > IV > V

13. To avoid the precipitation of hydroxides of Ni^{2+}, Co^{2+}, Zn^{2+} and Mn^{2+} along with those of Fe^{3+}, Al^{3+} and Cr^{3+} the third group solution should be
(a) heated with a few drops of conc. HNO_3
(b) treated with excess of NH_4Cl
(c) concentrated
(d) None of these.

14. In acidic medium, $KMnO_4$ oxidises $FeSO_4$ solution. Which of the following statements is correct?
(a) 10 mL of 1 N $KMnO_4$ solution oxidises 10 mL of 5 N $FeSO_4$ solution.
(b) 10 mL of 1 M $KMnO_4$ solution oxidises 10 mL of 5 M $FeSO_4$ solution.
(c) 10 mL of 1 M $KMnO_4$ solution oxidises 10 mL of 1 M $FeSO_4$ solution.
(d) 10 mL of 1 N $KMnO_4$ solution oxidises 10 mL of 0.1 M $FeSO_4$ solution.

15. Graph between log k and $1/T$ [where k is rate constant (in s^{-1}) and T is the temperature (in K)] is a straight line with $OX = 5$, $\theta = \tan^{-1}(1/2.303)$. Hence, $-E_a$ will be



(a) 2.303 × 2 cal (b) $\frac{2}{2.303}$ cal
(c) 2 cal (d) none of these.

16. When aluminium is heated in atmosphere of nitrogen it forms a nitride of formula
(a) AlN (b) Al_3N (c) AlN_3 (d) Al_2N_3

17. The order of the magnitude of ionic radii of ions N^{3-}, O^{2-} and F^- is
(a) $N^{3-} > O^{2-} > F^-$ (b) $N^{3-} < O^{2-} < F^-$
(c) $N^{3-} > O^{2-} < F^-$ (d) $N^{3-} < O^{2-} > F^-$

18. NH_4^+ is isostructural with
(a) CH_3^- (b) CH_3^+ (c) H_3O^+ (d) SO_4^{2-}

19. Aspartame is one of the good artificial sweeteners whose use is limited to cold foods and soft drinks because
(a) aspartame has very high boiling point
(b) aspartame gets dissociated at cooking temperature
(c) aspartame is sweetener at low temperature only
(d) aspartame is not soluble at higher temperatures.

20. Phenol associates in benzene to a certain extent to form dimer. A solution containing 2.0×10^{-2} kg of phenol in 1.0 kg of benzene has its freezing point

For the SCIENTIST in YOU

Researchers develop zero-emission technology to manage and recycle e-waste to wealth

E-waste contains several toxic materials such as lead, cadmium, chromium, brominated flame retardants or polychlorinated biphenyls. Therefore, unregulated accumulation, landfilling or inappropriate recycling processes poses a severe threat to human health and the environment.

On the contrary, e-waste can also be considered an "Urban Mine" for metal recovery and energy production. Researchers has developed a sustainable technology to tackle the menace of e-waste.

The developed technology will cater to the need of "Smart Cities," "Swachh Bharat Abhiyan," and "Atmanirbhar Bharat" initiatives of the Indian government via waste to wealth generation in decentralized units.

The adopted methodology is a three-step process: (i) Pyrolysis of e-waste (ii) Separation of metal fraction, and (iii) Recovery of individual metals.

Firstly, e-waste is shredded and pyrolyzed to yield liquid and gaseous fuels, leaving behind a metal-rich solid fraction. On further separation using a novel technique, the leftover solid residue yields a 90-95% pure metal mixture and some carbonaceous materials. The carbonaceous material is further converted to aerogel for oil spillage cleaning, dye removal, carbon dioxide capture and use in supercapacitors.

In the next step, a low-temperature roasting technique is employed to recover individual metals such as copper, nickel, lead, zinc, silver and gold from the metal mixture. It gives a recovery of nearly 93% copper, 100% nickel, 100% zinc, 100% lead and 50% gold and silver each. It is a green process in which no toxic chemicals are released into the environment.

The researchers team has successfully installed a 10 kg/h (Kilogram per hour) pyrolysis plant for e-waste recycling at IIT Delhi. It converts all types of e-waste to combustible gases of 28 MJ/kg (Megajoule per Kilogram) calorific value, liquid fuel of 30 MJ/kg calorific value, and a metal-rich solid residue. The gaseous product obtained from the pilot plant is primarily composed of hydrogen and methane whereas the liquid product is rich in hydrocarbons suitable for energy generation. The pilot plant is also equipped with a scrubbing system that captures halogenated compounds traces in the combustible gases.

decreased by 0.69 K. The degree of association of phenol is
(K_f for benzene = 5.12 K kg mol^{-1})
(a) 73.4% (b) 50.1% (c) 42.3% (d) 25.1%

21. Aldol condensation is a characteristic reaction of
(a) all aldehydes and ketones
(b) only those aldehydes and ketones which contain α-hydrogen atoms
(c) only those aldehydes and ketones which do not contain α-hydrogen atoms
(d) only aromatic aldehydes and ketones.

22. Nitrobenzene on reduction with $LiAlH_4$ in the presence of ether gives
(a) aniline
(b) benzene
(c) azobenzene
(d) *N*-phenylhydroxylamine.

23. Correct IUPAC name of the given compound is

(a) 3-methyl-3-cyclopentylbutanoic acid
(b) 2-methyl-2-cyclopentylbutanoic acid
(c) 1,1-dimethyl-1-cyclopentylethanoic acid
(d) 2-methyl-3-cyclopentylbutanoic acid.

24. Chemical '*A*' is used for water softening to remove temporary hardness. '*A*' reacts with sodium carbonate to generate caustic soda. When CO_2 is bubbled through '*A*', it turns cloudy. What is '*A*'?
(a) $CaCO_3$ (b) CaO
(c) $Ca(OH)_2$ (d) $Ca(HCO_3)_2$

25. The following quantum numbers are possible for how many orbitals? $n = 3$, $l = 2$, $m = +2$
(a) 1 (b) 2 (c) 3 (d) 4

26. The maximum concentration of M^+ ions that can be attained in a saturated solution of M_2SO_4 at 298 K is ($K_{sp} = 1.2 \times 10^{-5}$)
(a) 7.0×10^{-3} M (b) 3.46×10^{-3} M
(c) 2.88×10^{-2} M (d) 14.4×10^{-3} M

27. Hard steel can be further hardened by heating it to red hot and then cooling it by plunging it into cold water, this process is called
(a) annealing (b) quenching
(c) smelting (d) tempering.

28. The equilibrium $Cr_2O_7^{2-} \rightleftharpoons 2CrO_4^{2-}$ is shifted to right in
(a) an acidic medium (b) an alkaline medium
(c) neutral medium (d) aqueous medium.

29. The hormone that controls the contraction of the uterus after child birth and releases milk from the mammary glands is
(a) oxytocin (b) vasopressin
(c) thyroxine (d) adrenaline.

30. A solution of (+)-1-chloro-1-phenylethane in toluene racemises slowly in the presence of a small amount of $SbCl_5$, due to the formation of
(a) carbanion (b) carbene
(c) free radical (d) carbocation.

31. 2.0 g of oxygen contains number of atoms equal to that in
(a) 4.0 g of sulphur (b) 7.0 g of nitrogen
(c) 0.5 g of hydrogen (d) 2.3 g of sodium.

32. Which of the following statements is not correct?
(a) Some antiseptics can be added to soaps.
(b) Dilute solutions of some disinfectants can be used as an antiseptic.
(c) Disinfectants are antimicrobial drugs.
(d) Antiseptic medicines can be ingested.

33. At low pressure, the van der Waals equation is reduced to
(a) $Z = \frac{PV_m}{RT} = 1 - \frac{a}{RTV_m}$

(b) $Z = \frac{PV_m}{RT} = 1 + \frac{bP}{RT}$

(c) $PV_m = RT$

(d) $Z = \frac{PV_m}{RT} = 1 - \frac{a}{RT}$

34. Given $\Lambda^\circ\left(\frac{1}{3}Al^{3+}\right) = 63\ \Omega^{-1}\ cm^2\ mol^{-1}$ and $\Lambda^\circ\left(\frac{1}{2}SO_4^{2-}\right) = 80\ \Omega^{-1}\ cm^2\ mol^{-1}$. The value of $\Lambda^\infty[Al_2(SO_4)_3]$ would be (in $\Omega^{-1}\ cm^2\ mol^{-1}$)

(a) 143 (b) 206

(c) 286 (d) 858

35. The rate constant of a first order reaction increases by 6 times when its temperature is raised from 27° to 28°C. The activation energy of the reaction is

(a) 43.7 kJ/mol (b) 17.5 kJ/mol

(c) 47.5 kJ/mol (d) 27.5 kJ/mol.

36. The volume of carbon dioxide gas evolved at S.T.P. by heating 7.3 g of $Mg(HCO_3)_2$ will be

(a) 2240 mL (b) 1120 mL

(c) 2340 mL (d) 2000 mL.

37. Photochemical smog occurs in warm, dry and sunny climate. One of the following is not amongst the components of photochemical smog. Identify it.

(a) NO_2 (b) O_3

(c) SO_2

(d) Unsaturated hydrocarbons

38. The compound which is not isomeric with diethyl ether is

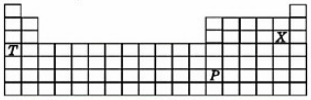
(a) *n*-propyl methyl ether

(b) butan-l-ol

(c) 2-methylpropan-2-ol

(d) butan-2-one.

39. Which of the following is correct increasing order of pH of the hydroxide solution of *T*, *P* and *X*?



(a) $T < P < X$ (b) $X < P < T$

(c) $P < T < X$ (d) $P < X < T$

40. Of the following statements about enzymes, which one is true?

(i) Enzymes lack in specific active sites.

(ii) Enzymes are highly specific both in binding chiral substrates and in catalysing their reactions.

(iii) Enzymes catalyse chemical reactions by lowering the activation energy.

(iv) Pepsin is a proteolytic enzyme.

(a) (i) and (iv) (b) (i) and (iii)

(c) (ii), (iii) and (iv) (d) only (i).

41. Which of the following is aromatic?

(a)  (b)  (c) (d) 

42. The factor of ΔG values is important in metallurgy. The ΔG values for the following reactions at 800°C are given as :

$S_{2(g)} + 2O_{2(g)} \rightarrow 2SO_{2(g)}$; $\Delta G = -544$ kJ

$2Zn_{(s)} + S_{2(g)} \rightarrow 2ZnS_{(s)}$; $\Delta G = -293$ kJ

$2Zn_{(s)} + O_{2(g)} \rightarrow 2ZnO_{(s)}$; $\Delta G = -480$ kJ

The ΔG for the reaction,

$2ZnS_{(s)} + 3O_{2(g)} \rightarrow 2ZnO_{(s)} + 2SO_{2(g)}$ will be

(a) −731 kJ (b) −773 kJ

(c) −229 kJ (d) −357 kJ.

43. The correct decreasing order of acidic character is

(a) HClO > HBrO > HIO

(b) HIO > HBrO > HClO

(c) HBrO > HIO > HClO

(d) HClO > HIO > HBrO

44. In vulcanisation of rubber

(a) sulphur reacts to form a new compound

(b) sulphur cross-links are introduced

(c) sulphur forms a very thin protective layer over rubber

(d) all statements are correct.

45. When 0.1 mol $CoCl_3(NH_3)_5$ is treated with excess of $AgNO_3$, 0.2 mol of AgCl are obtained. The conductivity of solution will correspond to

(a) 1 : 3 electrolyte (b) 1 : 2 electrolyte

(c) 1 : 1 electrolyte (d) 3 : 1 electrolyte.

SOLUTIONS

1. **(d):** SO_4^{2-} and ClO_4^- both are tetrahedral.

2. **(c):** The free radical (c) is stabilised by resonance due to the presence of phenyl group as a substituent.

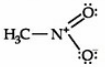
3. **(d):** The relative ease of dehydration of alcohols follows the order 3° > 2° > 1°.

4. **(a):** $\rho = \frac{Z \times M}{a^3 \times N_A} \Rightarrow 9.5 = \frac{1 \times 300}{a^3 \times 6.02 \times 10^{23}}$

or $a^3 = 5.245 \times 10^{-23} \Rightarrow a = 3.74 \times 10^{-8}$ cm

For simple cubic, $r = \frac{a}{2} = 1.87 \times 10^{-8}$ cm

5. **(c):** The Lewis structure of CH_3NO_2 has a formal charge of +1 on nitrogen, making it more electron attracting than the other structures.



6. **(a):** Given : $n = 1$, $P_1 = 1$ bar, $P_2 = 0.1$ bar, $T = 273$ K

$w = -2.303\, nRT \log \frac{P_1}{P_2}$

$= -2.303 \times 1 \times 8.314 \times 273 \log \frac{1}{0.1}$

$= -2.303 \times 1 \times 8.314 \times 273 \times 1$

$= -5227$ J $= -5.227$ kJ

For isothermal expansion, $\Delta U = 0$

$\therefore \quad q = -w$

$\therefore \quad q = -(-5.227)$ kJ $= +5.227$ kJ

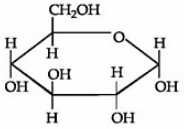
7. **(a):** Clean water must have BOD value of less than 5 ppm *i.e.*, rich in dissolved oxygen.

8. **(d):** Allylic halides : 

Benzylic halides : 

Vinylic halides : 

9. **(c):** The cyclic structure of α-*D*-glucose represents Haworth projection formula of α-*D*-glucose.



10. **(d):** $3B_2H_6 + 6NH_3 \longrightarrow 3[BH_2(NH_3)_2]^+ [BH_4]^- \xrightarrow{\Delta} 2B_3N_3H_6 + 12H_2$

Borazine

11. **(c):** (I) 1 mole of Ar contains 6.023×10^{23} atoms

52 moles of Ar will contain $6.023 \times 10^{23} \times 52$

$= 3.13 \times 10^{25}$ atoms

(II) 4 u of He = 1 atom

52 u of He $= \frac{1}{4} \times 52 = 13$ atoms

(III) 4 g of He contain 6.023×10^{23} atoms

52 g of He will contain

$= \frac{6.023 \times 10^{23} \times 52}{4} = 7.83 \times 10^{24}$ atoms

Therefore, the correct increasing order is

(II) < (III) < (I).

12. **(b):** More the electron withdrawing effect, the compound will be more acidic. More the number of halogen atoms, greater would be the dispersion of the negative charge. Hence, more will be stabilisation of anion and the compound will be more acidic. More the value of pK_a, less acidic will be the compound. Smaller the value of pK_a, the compound will be more acidic.

13. **(b):** Hydroxides of third group elements are precipitated by adding excess of solid NH_4Cl to the solution followed by addition of excess of NH_4OH. Due to common ion effect the degree of dissociation of NH_4OH gets suppressed and hence the concentration of OH^- ions in the solution decreases which results in precipitation of only group III hydroxides having low solubility products and not the group IV hydroxides which have high solubility products.

14. **(b):** $2KMnO_4 + 8H_2SO_4 + 10FeSO_4 \longrightarrow K_2SO_4 + 2MnSO_4 + 5Fe_2(SO_4)_3 + 8H_2O$

One mole of $KMnO_4$ oxidises five moles of $FeSO_4$ *i.e.*, 1 M $KMnO_4$ can oxidise equal amount of 5 M $FeSO_4$.

15. **(c):** $\log k = \log A - \frac{E_a}{2.303RT}$

$\text{Slope} = \frac{-E_a}{2.303R} = \tan\theta = \frac{1}{2.303}$ (given)

$-E_a = 2.303R \times \text{Slope} = 2.303R \times \frac{1}{2.303} = R = 2$ cal

16. **(a):** Aluminium when heated with nitrogen forms aluminium nitride.

$2Al + N_2 \longrightarrow 2AlN$

17. **(a)**

18. **(d):** Both NH_4^+ and SO_4^{2-} have tetrahedral shape showing sp^3 hybridisation.

19. **(b):** Aspartame is unstable at cooking temperature thus gets dissociated.

20. (a): $M_2(\text{obs}) = \dfrac{K_f \times w \times 1000}{W \times \Delta T_f}$

$$= \frac{5.12 \times 2.0 \times 10^{-2} \times 1000}{1.0 \times 0.69} = 148.4$$

Calculated molecular mass of phenol = 94

$$i = \frac{M_2(\text{cal})}{M_2(\text{obs})} = \frac{94}{148.4} = 0.633$$

$$\underset{1-\alpha}{2C_6H_5OH} \rightleftharpoons \underset{\alpha/2}{(C_6H_5OH)_2}$$

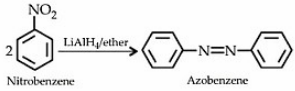
Total species $= (1-\alpha) + \dfrac{\alpha}{2} = 1 - \dfrac{\alpha}{2}$

$$i = \frac{1-\alpha/2}{1} \quad \text{or} \quad \frac{\alpha}{2} = 1 - i$$

or $\alpha = 2(1-i) = 2(1-0.633) = 0.734 = 73.4\%$

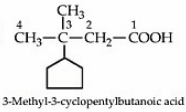
21. (b)

22. (c): Aromatic nitro compounds on reduction with $LiAlH_4$ give azo compounds and not primary amines.



Nitrobenzene Azobenzene

23. (a):



3-Methyl-3-cyclopentylbutanoic acid

24. (c): $\underset{(A)}{Ca(OH)_2} + Ca(HCO_3)_2 \longrightarrow 2CaCO_3\downarrow + 2H_2O$ (Clark's method)

$$\underset{(A)}{Ca(OH)_2} + Na_2CO_3 \longrightarrow CaCO_3\downarrow + 2NaOH$$ Caustic soda

$$\underset{(A)}{Ca(OH)_2} + CO_2 \longrightarrow \underset{\text{Calcium carbonate}}{CaCO_3} + H_2O$$

(cloudy)

25. (a): One set of quantum numbers is only for one orbital. In an atom, the two electrons in the same orbital can have the same set of three quantum numbers with a different value for spin quantum number.

26. (c): $M_2SO_4 \rightleftharpoons 2M^+ + SO_4^{2-}$

$$K_{sp} = [M^+]^2[SO_4^{2-}] = (2s)^2(s) = 4s^3$$

$$\text{or} \quad s = \left(\frac{1.2 \times 10^{-5}}{4}\right)^{1/3} = 1.44 \times 10^{-2}$$

$\therefore$ Concentration of M^+ ions $= 2s = 2.88 \times 10^{-2}$ M

27. (b): If a steel article is heated to redness and then suddenly cooled by plunging into water or some oil, the steel becomes hard and brittle. This treatment is called quenching or hardening of steel.

28. (b): When an alkali is added to dichromate solution then chromate salt formation takes place.

$$Cr_2O_7^{2-} + 2OH^- \longrightarrow 2CrO_4^{2-} + H_2O$$

29. (a)

30. (d): 1-Chloro-1-phenylethane racemises *i.e.*, it proceeds *via* the formation of carbocation.

Some Major Achievements in the field of Scientific and Technological Development

- ARCI's develop easy to clean coating on car windshield glass in cleaning action after pouring the muddy water.
  Glass is an amorphous, non-crystalline, more or less transparent material. Self-cleaning glass is a special types of glass that needs minimal maintenance because its surface has been designed to keep itself free from dirt and grime. Nanotechnology is used for the fabrication of this special glass in which an ultra-thin coating is applied to achieve the self-cleaning property. Self-cleaning glass is of two types: hydrophilic and hydrophobic. In the former, a tiny coating of titania is used and in the latter a thin layer of silica coating is applied through nanotechnology. Glare-free glass that does not fog has the benefit of preventing spectacles from misting up when the wearer is drinking a hot beverage in winter. Additionally, it enables tablet computers to be used near swimming pools and minimizes the amount of cleaning needed for glass windows and doors.
- IASST scientists developed an electrochemical sensing platform using carbon dots for detecting toxic chemicals *N*-nitrosodimethylamine (NDMA) and *N*-nitrosodiethanolamine (NDEA). These toxic chemicals may alter the chemical composition of our DNA leading to cancer. Cured meats, bacon, some cheese, low fat dry milk are some sources which may contain these chemicals of Nitrosamine family.
- International Advanced Research Centre for Powder Metallurgy and New Materials (ARCI), Hyderabad synthesized aluminum hydride (also known Alane) at lab-scale by electrochemical methods and direct hydrogenation approach for hydrogen storage applications. Also, developed Glucose sensors, at lab scale, as a value-added application of recycled Pt-catalysts from end of life PEMFC electrodes.
- Scientists of Institute of Nano Science and Technology (INST) shown that ultra-high mobility electron gas can increase information, transfer speed & data storage density in quantum devices. According to INST Researchers, an ultra-high mobility of 2D-electrons gas (2DEG) produced at the novel interface composed of chemicals EuO and $KTaO_3$. The strong spin-orbit coupling and relativistic nature of the electrons in the 2DEG resulted in the 'Rashba field'. This open up a new field of quantum technology applicable for next generation data storage media and quantum computers.

31. (a): Number of atoms in 1 gram of an element

$$= \frac{6.023\times10^{23}}{\text{At. mass}}\times1$$

$\therefore$ Number of atoms in 2 grams of oxygen

$$= \frac{6.023\times10^{23}}{16}\times2 = \frac{6.023\times10^{23}}{8}$$

Number of atoms in 4 grams of sulphur

$$= \frac{6.023\times10^{23}}{32}\times4 = \frac{6.023\times10^{23}}{8}$$

Number of atoms in 7 grams of nitrogen

$$= \frac{6.023\times10^{23}}{14}\times7 = \frac{6.023\times10^{23}}{2}$$

Number of atoms in 0.5 gram of hydrogen

$$= \frac{6.023\times10^{23}}{1}\times0.5 = \frac{6.023\times10^{23}}{2}$$

Number of atoms in 2.3 grams of sodium

$$= \frac{6.023\times10^{23}}{23}\times2.3 = \frac{6.023\times10^{23}}{10}$$

32. (d) **33. (a)**

34. (d): $\Lambda^\circ(Al^{3+}) = 3\Lambda^\circ\left(\frac{1}{3}Al^{3+}\right)$

$= 3 \times 63 = 189\ \Omega^{-1}\ cm^2\ mol^{-1}$

$\Lambda^\circ\left(SO_4^{2-}\right) = 2\Lambda^\circ\left(\frac{1}{2}SO_4^{2-}\right)$

$= 2 \times 80 = 160\ \Omega^{-1}\ cm^2\ mol^{-1}$

$\Lambda^\circ[Al_2(SO_4)_3] = 2\ \Lambda^\circ(Al^{3+}) + 3\Lambda^\circ\left(SO_4^{2-}\right)$

$= 2 \times 189 + 3 \times 160$

$= 858\ \Omega^{-1}\ cm^2\ mol^{-1}$

35. (a): 6 times increase in rate constant, thus $k_2 = 1.06k_1$

$$\log\frac{k_2}{k_1} = \frac{E_a}{2.303R}\left(\frac{T_2 - T_1}{T_1T_2}\right)$$

$$\log\frac{1.06}{1} = \frac{E_a}{2.303\times8.314}\left(\frac{1}{300\times301}\right) = 43.7\ \text{kJ/mol}$$

36. (a): $Mg(HCO_3)_2 \rightarrow MgO + 2CO_2 + H_2O$

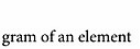
146 g of $Mg(HCO_3)_2$ gives 22.4 × 2 litre of CO_2

$\Rightarrow$ 7.3 g of $Mg(HCO_3)_2$ will give $\frac{22.4}{146}\times7.3\times2$

$= 2.24$ L of $CO_2 = 2240$ mL of CO_2

37. (c): The common components of photochemical smog are NO_2, O_3 and unburnt hydrocarbons.

38. (d): Diethyl ether ($C_2H_5OC_2H_5$), *n*-propyl methyl ether ($CH_3CH_2CH_2OCH_3$), butan-1-ol ($CH_3CH_2CH_2CH_2OH$),

2-methylpropan-2-ol  all have

molecular formula $C_4H_{10}O$, hence these are isomeric with diethyl ether. The molecular formula of butan-2-one ($CH_3CH_2COCH_3$) is different, it is C_4H_8O. So, it is not isomeric with diethyl ether.

39. (b) **40. (c)**

41. (b): Aromaticity can be predicted by the use of Huckle's rule which says that $(4n + 2)$ π-electrons are required in delocalisation system to give it aromaticity.

$(4n + 2)\pi$ electrons means 2, 6, 10 .....π electrons.

Here total number of electrons available for delocalisation is 6. Therefore, it is expected to be aromatic.

42. (a): $\Delta G_{reaction} = \Delta G_1 - \Delta G_2 + \Delta G_3$

$= -544 + 293 - 480 = -731$ kJ

43. (a): Acidity decreases as the electronegativity of the central halogen decreases from Cl to I in HXO.

44. (b): In vulcanisation of rubber, sulphur forms cross-links to make rubber more elastic.

45. (b): Formation of 0.2 mol of AgCl from 0.1 mol of the complex means that there are two ionizable Cl. Hence, formula is $[Co(NH_3)_5Cl]Cl_2$, *i.e.*, 1 : 2 type electrolyte.

❖❖

GEAR UP for JEE MAIN 2021

Exam Dates 2021
27th to 30th April; 24th to 28th May

Section A will be of Multiple Choice Questions (MCQs). Section B will contain questions whose answers are to be filled in as a Numerical Value. In Section B candidates have to attempt any five questions out of 10.

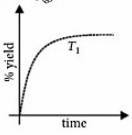
SECTION A (MULTIPLE CHOICE QUESTIONS)

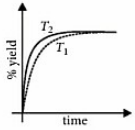
1. The density of solid argon is 1.65 g/mL at –233°C. If the argon atom is assumed to be a sphere of radius 1.54×10^{-8} cm, then the percentage of empty space in solid argon is
   (a) 54% (b) 82% (c) 62% (d) 48%

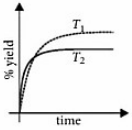
2. The correct ionic reaction for leaching process is
   (a) $Au + 2CN^- \longrightarrow Au[(CN)_2]^-$
   (b) $Zn + 2CN^- \longrightarrow Zn[(CN)_2]^-$
   (c) $4Au + 8CN^- + 2H_2O + O_2\ (air) \longrightarrow 4[Au(CN)_2]^-\ (soluble) + 4OH^-$
   (d) $Zn + 4CN^- \longrightarrow Zn[(CN)_4]^{2-}$

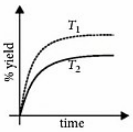
3. $C_2H_5OH + SOCl_2 \xrightarrow{Pyridine} C_2H_5Cl + SO_2 + HCl$
   The above reaction is known as
   (a) Williamson's reaction
   (b) Hofmann's reaction
   (c) Mendies reaction
   (d) Darzen's reaction.

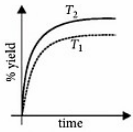
4. The % yield of ammonia as a function of time in the reaction, $N_{2(g)} + 3H_{2(g)} \rightleftharpoons 2NH_{3(g)}$, $\Delta H < 0$ at (P, T_1) is given below.
   If this reaction is conducted at (P, T_2), with $T_2 > T_1$, the % yield of ammonia as a function of time is represented by



(a)


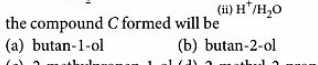
(b)


(c)


(d)


5. Correct statements about the hydrogen halides include that
   I. they are all coloured
   II. their thermal stability decreases with increasing atomic number of the halogen
   III. they all form soluble silver salts
   IV. they all donate protons to water.
   (a) I, II, III are correct (b) I, III are correct
   (c) II, IV are correct (d) IV is correct.

6. In the following sequence of reactions,



   the compound C formed will be
   (a) butan-1-ol (b) butan-2-ol
   (c) 2-methylpropan-1-ol (d) 2-methyl-2-propanol

7. Consider the following statements :
   I. Atomic hydrogen is obtained by molecular hydrogen on a hot filament of tungsten or platinum.
   II. Hydrogen gas will not reduce heated aluminium oxide.
   III. Finely divided palladium adsorbs large volume of hydrogen gas.
   IV. Nascent hydrogen is less active than ordinary hydrogen.
   Which of the above statements are correct?
   (a) Only I and II (b) Only II and IV
   (c) Only I, II and III (d) Only I and IV

8. Match the Column I with Column II and mark the appropriate choice.

Column I	Column II
(A) Edman reagent	(i) Phenyl isothiocyanate
(B) Tollens' reagent	(ii) Ammoniacal silver nitrate solution
(C) Lucas reagent	(iii) Sodium nitrite in conc. H_2SO_4
(D) Liebermann reagent	(iv) Anhydrous zinc chloride and conc. HCl

(a) (A) → (ii), (B) → (iii), (C) → (i), (D) → (iv)
(b) (A) → (i), (B) → (iii), (C) → (ii), (D) → (iv)
(c) (A) → (iii), (B) → (i), (C) → (ii), (D) → (iv)
(d) (A) → (i), (B) → (ii), (C) → (iv), (D) → (iii)

9. The dispersed phase in colloidal iron (III) hydroxide and colloidal gold is positively and negatively charged, respectively. Which of the following statements is NOT correct?
(a) Magnesium chloride solution coagulates, the gold sol more readily than the iron (III) hydroxide sol.
(b) Sodium sulphate solution causes coagulation in both sols.
(c) Mixing of the sols has no effect.
(d) Coagulation in both sols can be brought about by electrophoresis.

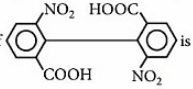
10. The optically active tartaric acid is named as *D*-(+) tartaric acid because it has a positive
(a) optical rotation and is derived from *D*-glucose
(b) pH in organic solvent
(c) optical rotation and is derived from *D*-(+)-glyceraldehyde
(d) optical rotation only when substituted by deuterium.

11. The line spectra of two elements are not identical because
(a) the elements do not have the same number of neutrons
(b) they have different mass numbers
(c) their outermost electrons are at different energy levels
(d) they have different valencies.

12. In context with the transition elements, which of the following statements is incorrect?
(a) In addition to the normal oxidation states, the zero oxidation state is also shown by these elements in complexes.
(b) In the highest oxidation states, transition metals show basic character and form cationic complexes.
(c) In the highest oxidation states of the first five transition elements (Sc to Mn), all the 4*s* and 3*d* electrons are used for bonding.
(d) Once the d^5 configuration is exceeded, the tendency to involve all the 3*d* electrons in bonding decreases.

13. Which of the following is correct?
(a) On reduction, any aldehyde gives secondary alcohol.
(b) Reduction of vegetable oil with H_2SO_4 gives glycerine.
(c) Alcoholic iodine with NaOH gives iodoform.
(d) Sucrose on reduction with NaCl gives invert sugar.

14. In two containers, *X* and *Y*, same gas is filled. If the pressure, volume and absolute temperature of gas in *X* are three times as compared to that in *Y* and if the mass of *X* is *m* g, the mass of *Y* is
(a) *m* g (b) *m*/3 g (c) *m*/2 g (d) 2*m* g

15. The IUPAC name of  is
(a) 6,6′-Dinitrodiphenic acid
(b) 6,6′-Dinitrobiphenyl-2,2′-dicarboxylic acid
(c) 2,2′-Dinitrobiphenyl-6,6′-dicarboxylic acid
(d) 2,2′-Dinitrodiphenic acid.

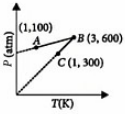
16. From the following reactions,

$$HC \equiv CH + LiNH_2 \rightleftharpoons NH_3 + HC \equiv CLi$$

$$NH_3 + R^- \rightleftharpoons NH_2^- + RH$$

Predict which of the following orders regarding acid strength is correct?
(a) $RH < NH_3 < HC \equiv CH$
(b) $RH > NH_3 > HC \equiv CH$
(c) $RH > NH_3 < HC \equiv CH$
(d) $RH < NH_3 > HC \equiv CH$

17. One mole of an ideal gas is subjected to a two step reversible process (*A*–*B* and *B*–*C*). The pressure at *A* and *C* is same. Mark the correct statement(s).



(a) Work involved in the path AB is zero.
(b) Volume of gas at A = volume of gas at B.
(c) Volume of gas at $C = 3 \times$ volume of gas at A.
(d) Volume of gas at B is 25 litres.

18. Chlorine is prepared in the laboratory by treating manganese dioxide (MnO_2) with aqueous hydrochloric acid according to the reaction,

$4HCl_{(aq)} + MnO_{2(s)} \rightarrow 2H_2O_{(l)} + MnCl_{2(aq)} + Cl_{2(g)}$

How many grams of HCl react with 5.0 g of manganese dioxide?

(a) 8.4 g (b) 5.5 g (c) 3.4 g (d) 4.8 g

19. The chemical reactions involve in the ammonia-soda process are represented as follows :

$2NaCl + CaCO_3 \longrightarrow Na_2CO_3 + CaCl_2$

In the following reaction, $CaCO_3 \xrightarrow{\Delta} [A] + [B]$

$NaCl + NH_3 + [B] + H_2O \longrightarrow [C] + [D]$

$2[C] \xrightarrow{\Delta} Na_2CO_3 + H_2O + [B]$

Identify A to D.

(a) A–Ca(OH)$_2$; B-CaO; C-NH_4Cl; D-$NaHCO_3$
(b) A-CaO; B-CO_2; C-$NaHCO_3$; D-NH_4Cl
(c) A-CO_2; B-$CaOCl_2$; C-$NaHCO_3$; D-NaCl
(d) A-$CaCl_2$; B-CO_2; C-Na_2CO_3; D-NaOH.

20. $CH_3OC_2H_5$ and $(CH_3)_3COCH_3$ are treated with hydroiodic acid. The fragments obtained after reaction are respectively

(a) $CH_3I + C_2H_5OH$; $(CH_3)_3C—I + CH_3OH$
(b) $CH_3OH + C_2H_5I$; $(CH_3)_3C—I + CH_3OH$
(c) $CH_3OH + C_2H_5I$; $(CH_3)_3C—OH + CH_3I$
(d) $CH_3I + C_2H_5OH$; $CH_3I + (CH_3)_3C—OH$

SECTION B (NUMERICAL VALUE TYPE)

21. An organic compound X with molecular formula C_xH_yO (having minimum no. of C-atoms) on treatment with $K_2Cr_2O_7$ gives compound Y which reacts with I_2 and Na_2CO_3 to form triiodomethane. Then the value of $x \times y$ is _____.

22. The rate constant for the first order decomposition of a certain reaction is described by the equation,

$$\log(k) = 13.12 - \frac{1.25 \times 10^4}{T}$$

The energy of activation (in kJ mol^{-1}) for this reaction will be _____.

23. The total number of inner-orbital complexes among the following is _____.

$[Pt(NH_3)_6]^{4+}$, $[Ni(H_2O)_6]^{2+}$, $[Fe(CN)_6]^{4-}$, $[Fe(H_2O)_6]^{3+}$, $[Co(CN)_6]^{3-}$, $[Ir(NH_3)_6]^{3+}$, $[CoF_6]^{3-}$

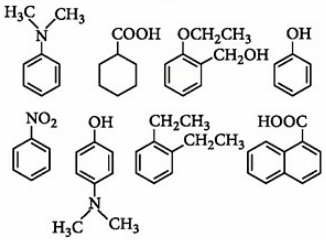
24. The emf of the given cell is _____.

$Ag(s), AgIO_3(s)|Ag^+(xM), HIO_3(1M)||Zn^{2+}(1M)|\ Zn(s)$

If $K_{sp} = 3 \times 10^{-8}$ for $AgIO_3$ and $K_a = \frac{1}{6}$ for HIO_3 and E°_{cell} for $2Ag + Zn^{2+} \longrightarrow 2Ag^+ + Zn$ is – 1.56 V

(Given : log 3 = 0.48, $\frac{2.303\ RT}{F} = 0.06$)

25. Amongst the following, the total number of compounds soluble in aqueous NaOH is _____.



26. 25 mL of 2 N HCl, 50 mL of 4 N HNO_3 and x mL of 5 M H_2SO_4 are mixed together and the total volume is made up to 1 L with water, 50 mL of this acid mixture exactly neutralizes 25 mL of a 1 N Na_2CO_3 solution. The value of x is _____.

27. If HCl is assumed to be completely polar then the expected value of dipole moment is 6.12 D but its experimental value is found to be 1.03 D. The percentage ionic character in HCl is _____.

28. One mole of X_2H_4 releases 10 moles of electrons to form a compound Y. What should be the oxidation number of X in the compound Y?

29. An organic compound (A) fumes in moist air and reacts with cold water to give an acid (B). Acid (B) reacts with NH_3 to give an amide (C). (C) on heating with P_2O_5 gives propane nitrile. The number of acyclic functional isomers of (A) is _____.

30. The number of pairs in which size of first element/ion is higher as compared to second out of the following pairs is _____.

(O, S), (He, Ne), (Kr, Ne), (Na, Na^+), (Cl, Cl^-), (I^-, Cl^-), ($Li^+_{aq.}$, $Na^+_{aq.}$), (Li, Na), (Li^+, Na^+)

SOLUTIONS

1. (c) : Volume of one atom of Ar $= \frac{4}{3}\pi r^3$

Also, number of atoms in 1.65 g/mL

$= \frac{1.65}{40} \times 6.023 \times 10^{23}$

$\therefore$ Total volume of all the atoms of Ar in solid state

$= \frac{4}{3}\pi r^3 \times \frac{1.65}{40} \times 6.023 \times 10^{23}$

$= \frac{4}{3} \times \frac{22}{7} \times (1.54 \times 10^{-8})^3 \times \frac{1.65}{40} \times 6.023 \times 10^{23}$

$= 0.380\ cm^3$

Volume of solid Ar = $1\ cm^3$

$\therefore$ % empty space $= \frac{1 - 0.38}{1} \times 100 = 62\%$

2. (c) **3. (d)**

4. (b): $N_{2(g)} + 3H_{2(g)} \underset{\text{endo}}{\overset{\text{exo}}{\rightleftharpoons}} 2NH_{3(g)}; \Delta H < 0$

Initially, with increase in temperature ($T_2 > T_1$) % yield increases.

Afterwards, equilibrium is reached and if the temperature is increased, *i.e.*, heat is supplied to the system, then according to Le Chatelier's principle, the equilibrium will shift in the backward direction, where the heat is absorbed. Hence, the % yield decreases.

5. (c)

6. (d):

$$CH_3-\underset{\underset{NH_2}{|}}{CH}-CH_3 \xrightarrow{HNO_2} CH_3-\underset{\underset{OH}{|}}{CH}-CH_3 \xrightarrow{[O]} \underset{(B)}{CH_3-CO-CH_3} \xrightarrow[\text{(ii) } H^+/H_2O]{\text{(i) } CH_3MgI} \underset{\text{2-methyl-2-propanol}}{(CH_3)_3COH}$$

(A) (C)

7. (c) **8. (d)**

9. (c) : Opposite charges attract each other. Hence, on mixing mutual coagulation of two sols may take place.

10. (c) **11. (c)**

12. (b): When the transition metals are in their highest oxidation states, they no longer have tendency to give away electrons, thus they are not basic but show acidic character and form anionic complexes.

13. (c) : $C_2H_5OH + 4I_2 + NaOH \rightarrow CHI_3 + NaI + HCOONa + H_2O$

14. (b): We know, $\frac{PV}{T} = nR \Rightarrow n_x = 3n_y$

$$\frac{\text{Weight of gas in } X}{\text{Molecular weight}} = 3 \times \frac{\text{Weight of gas in } Y}{\text{Molecular weight}}$$

Weight of gas in $Y = \frac{m}{3}$ g

15. (b)

16. (a) : $HC \equiv CH + LiNH_2 \rightleftharpoons NH_3 + HC \equiv CLi$

$\Rightarrow HC \equiv CH > NH_3$

$NH_3 + R^- \rightleftharpoons NH_2^- + RH \Rightarrow NH_3 > RH$

Therefore, the correct order of acidic strength is $RH < NH_3 < HC \equiv CH$.

17. (c) : $V_A = \frac{1 \times R \times 100}{1} = 100\ R$

$V_B = \frac{1 \times R \times 600}{3} = 200\ R$

$V_C = \frac{1 \times R \times 300}{1} = 300\ R$

$\because \quad V_B > V_A$, so expansion of gas takes place.

$V_B = 200 \times 0.0821 = 16.42$ L

18. (a) : $\underset{\text{4 mol or 146 g}}{4HCl_{(aq)}} + MnO_{2(s)} \rightarrow 2H_2O_{(l)} + \underset{\text{1 mol or 87 g}}{MnCl_{2(aq)}} + Cl_{2(g)}$

87 g of MnO_2 reacts with 146 g of HCl.

$\therefore$ 5 g of MnO_2 will react with $\frac{146 \times 5}{87}$

$= 8.39 \approx 8.40$ g of HCl

19. (b)

20. (a) : In $CH_3OC_2H_5$, attack of I^- ion occurs at $-CH_3$ group giving CH_3I and C_2H_5OH. In contrast, in $(CH_3)_3COCH_3$, reaction occurs by S_N1 mechanism and I^- ion attacks the more stable $(CH_3)_3C^+$ giving $(CH_3)_3CI$ and CH_3OH.

21. (24) :

$$\underset{\underset{(C_3H_8O)}{(X)}}{CH_3-\underset{\underset{OH}{|}}{CH}-CH_3} \xrightarrow{K_2Cr_2O_7} \underset{\underset{\text{(Gives +ve iodoform test)}}{(Y)}}{CH_3-\overset{\overset{O}{||}}{C}-CH_3}$$

$\therefore \quad x = 3\ ;\ y = 8$

$\therefore \quad x \cdot y = (3 \times 8) = 24$

22. (239) : We know $k = A.e^{-E_a/RT}$

or $\log k = \log A - \frac{E_a}{2.303\,RT}$

Comparing this equation with the given equation,

we get, $\frac{E_a}{2.303R} = 1.25 \times 10^4$

Hence, $E_a = 1.25 \times 10^4 \times 2.303 \times 8.314$

$= 2.39 \times 10^5$ J mol^{-1} or 239 kJ mol^{-1}

23. (4) : $[Ni(H_2O)_6]^{2+}$, $[Fe(H_2O)_6]^{3+}$ and $[CoF_6]^{3-}$ are outer-orbital complexes having sp^3d^2 hybridisation. In these complexes, due to presence of weak field ligands *i.e.*, H_2O and F^-, pairing will not occur. Hence, shows sp^3d^2 hybridisation.

$[Pt(NH_3)_6]^{4+}$, $[Fe(CN)_6]^{4-}$, $[Co(CN)_6]^{3-}$ and $[Ir(NH_3)_6]^{3+}$ are inner-orbital complexes having d^2sp^3 hybridisation.

In these complexes, due to presence of strong field ligands *i.e.*, CN^- and NH_3, pairing will take place. Also Pt and Ir has high Δ_o value, therefore pairing will occur instead of filling electrons in other orbitals because of high energy requirement.

24. (1.137) : $K_a = \frac{C\alpha^2}{1-\alpha} \Rightarrow \frac{1}{6} = \frac{\alpha^2}{1-\alpha}$

$$\Rightarrow \quad \alpha = \frac{-1 \pm \sqrt{(1)^2 + 4 \times 6 \times 1}}{12} = \frac{-1 \pm \sqrt{1+24}}{12} = \frac{1}{3}$$

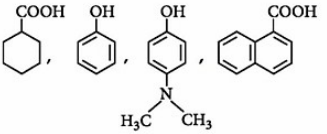
$\therefore [IO_3^-] = 1 \times \frac{1}{3} = \frac{1}{3}$

$$\Rightarrow \quad [Ag^+] = \frac{3 \times 10^{-8}}{1/3} = 9 \times 10^{-8}\,M$$

Now, $2Ag + Zn^{2+} \xrightarrow{2e^-} 2Ag^+ + Zn$

$$E_{cell} = -1.56 + \frac{0.06}{2}\log\frac{1}{(9\times10^{-8})^2} = -1.137\ V$$

25. (4) : Out of the given compounds, those soluble in aqueous NaOH are



26. (25) : Let N_1 be the normality of acid mixture and volume of H_2SO_4 be x mL.

Using the normality equation,

$(25 \times 2 + 50 \times 4 + x \times 5 \times 2) = 1000\ N_1$

$(50 + 200 + 10x) = 1000\ N_1$ ...(i)

Also, 50 mL of N_1 acid mixture
$= 25$ mL of 1 N Na_2CO_3

$\therefore \quad N_1 = \frac{1}{2} N$ ...(ii)

From equations (i) and (ii),

$$(250 + 10x) = 1000 \times \frac{1}{2}$$

$\Rightarrow \quad 250 + 10x = 500 \Rightarrow x = 25$ mL

27. (17) : Percentage ionic character

$$= \frac{\text{Experimental value of dipole moment}}{\text{Theoretical value of dipole moment}} \times 100$$

$$= \frac{1.03}{6.12} \times 100 = 16.8 \approx 17\%$$

28. (3): $\underset{(Y)}{X_2H_4} - 10e^- \longrightarrow (X_2H_4)^{+10}$

$2x + 4 = +10$

$\Rightarrow \quad x = +3$

So, oxidation number of X in the compound Y is 3.

29. (5): (C) is an amide which on heating with P_2O_5 gives propane nitrile and so, (C) is propanamide.

$$\underset{(C)}{CH_3CH_2CONH_2} \xrightarrow[-H_2O]{P_2O_5} \underset{\text{Propane nitrile}}{CH_3CH_2CN}$$

(C) is formed by the action of NH_3 on acid (B) so, acid (B) is propanoic acid.

$$\underset{(B)}{CH_3CH_2COOH} + NH_3 \longrightarrow CH_3CH_2COO^-NH_4^+$$

$$\underset{(C)}{CH_3CH_2CONH_2} \xleftarrow{\Delta}$$

Acid (B) is formed from hydrolysis of (A) as well as (A) fumes in moist air, so (A) is acid halide. Thus, (A) is

$$\underset{(A)}{CH_3CH_2COCl} + \underset{\text{Moist air}}{HOH} \rightarrow \underset{(B)}{CH_3CH_2COOH} + HCl\uparrow$$

Fumes in moist air

Hence, (A) is CH_3CH_2COCl (Propanoyl chloride).
(B) is CH_3CH_2COOH (Propanoic acid).
(C) is $CH_3CH_2CONH_2$ (Propanamide).
Acyclic functional isomers of (A) are

(i) CH_3CH_2COCl (ii) CH_3COCH_2Cl

(iii) $ClCH_2CH_2CHO$ (iv) $CH_2=\underset{\displaystyle Cl}{\underset{|}{C}}-CH_2OH$

(v) $CH_2=\underset{\displaystyle Cl}{\underset{|}{C}}-OCH_3$

30. (4): (Kr, Ne), (Na, Na^+), (I^-, Cl^-), ($Li^+_{(aq.)}$, $Na^+_{(aq.)}$)

JEE 2021 ADVANCED

Exam on 3rd July

PRACTICE PAPER

PAPER - I

Section 1 (Maximum Marks : 18)

- *This section contains SIX (06) questions.*
- *Each question has FOUR options. ONLY ONE of these four options is the correct answer.*
- *For each question, choose the option corresponding to the correct answer.*
- *Answer to each question will be evaluated according to the following marking scheme :*

Full Marks : +3 *If ONLY the correct option is chosen.*

Zero Marks : 0 *If none of the options is chosen (i.e. the question is unanswered).*

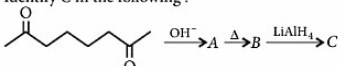
Negative Marks : −1 *In all other cases.*

1. Lanthanum has a stable isotope ^{139}La and a radioactive isotope ^{138}La with half-life 1.1×10^{10} years whose atoms are 0.1% of those of the stable isotope. The rate of decay or activity of ^{138}La with 1 kg of ^{139}La (Avogadro's number, $N = 6 \times 10^{23}$ mol^{-1}) is
   (a) 8623 s^{-1} (b) 8421 s^{-1}
   (c) 4001 s^{-1} (d) 3002 s^{-1}

2. $C_9H_{12}O(A)$ rotates the plane polarised light, evolves H_2 with Na metal, reacts with I_2 and NaOH to produce yellow ppt. of CHI_3. It reacts with Lucas reagent in five minutes. It does not react with Br_2/CCl_4. It reacts with hot $KMnO_4$ to form compound (B) $C_7H_6O_2$ which can be obtained by reaction of benzene with carbonyl chloride in presence of $AlCl_3$, followed by hydrolysis. It loses optical activity as a result of formation of compound (C) on being heated with HI and red P. Which of the following is incorrect?
   (a) The molar mass of (C) is 120 g/mol.
   (b) The compound (C) is isopropyl benzene.
   (c) The compound (A) is 1-phenylpropan-2-ol.
   (d) The compound (B) is benzoic acid.

3. The heat of hydrogenation of hex-1-ene is 126 kJ mol^{-1}. When a second double bond is introduced in the molecule, the heat of hydrogenation of the resulting compound is found to be 230 kJ mol^{-1}. The resulting compound will be
   (a) 1,5-hexadiene (b) 1,4-hexadiene
   (c) 1,3-hexadiene (d) 1,2-hexadiene.

4. Identify C in the following :



(a) 

(b) 

(c) 

(d) 

5. A colourless inorganic salt (A) decomposes completely at about 523 K to give only two products (B) and (C) leaving no residue. The product (B) is a neutral gas while the product (C) is a liquid at room temperature and is neutral to litmus. White phosphorus burns in excess of (B) to produce a strong dehydrating agent P_4O_{10}. The compounds (A), (B) and (C) are respectively
   (a) NH_4NO_2, N_2, H_2O (b) NH_4NO_3, N_2O, H_2O
   (c) NH_4Cl, NH_3, HCl (d) $NaNO_3$, O_2, $NaNO_2$

6. An alkyl bromide (A) was treated with excess of ammonia to give (B) as the major product. (B) was subsequently treated with one equivalent of CH_3I to give (C). (B) and (C) on treating with aqueous $NaNO_2$ and HCl give compounds (D) and (E) respectively. (D) on oxidation followed by decarboxylation gives ethane. The structure of the compound (E) is

(a) $CH_3CH_2CH_2CH_2-\underset{\underset{N=O}{|}}{N}-CH_3$

(b) $CH_3CH_2-\underset{\underset{N=O}{|}}{N}-CH_3$

(c) $(CH_3)_2CHCH_2-\underset{\underset{N=O}{|}}{N}-CH_3$

(d) $CH_3CH_2CH_2-\underset{\underset{N=O}{|}}{N}-CH_3$

Section 2 (Maximum Marks : 24)

- *This section contains SIX (06) questions.*
- *Each question has FOUR options. ONE OR MORE THAN ONE of these four option(s) is (are) correct answer(s).*
- *For each question, choose the option(s) corresponding to (all) the correct answer(s).*
- *Answer to each question will be evaluated according to the following marking scheme :*

Full Marks :	*+4*	*If only (all) the correct option(s) is (are) chosen.*
Partial Marks :	*+3*	*If all the four options are correct but ONLY three options are chosen.*
Partial Marks :	*+2*	*If three or more options are correct but ONLY two options are chosen, both of which are correct.*
Partial Marks :	*+1*	*If two or more options are correct but ONLY one option is chosen and it is a correct option.*
Zero Marks :	*0*	*If none of the options is chosen (i.e. the question is unanswered).*
Negative Marks :	*−2*	*In all other cases.*

7. A sample of H_2O_2 solution labelled as "28 volume" has density of 265 g/L. Mark the correct option(s) representing concentration of same solution in other units.

(a) $M_{H_2O_2} = 2.5$ (b) $\% \frac{w}{v} = 17$

(c) Mole fraction of $H_2O_2 = 0.2$

(d) $m_{H_2O_2} = 13.88$

8. Amongst the following compounds, the one(s) which readily react with ethanolic KCN is

(a) ethyl chloride (b) chlorobenzene

(c) benzaldehyde (d) salicylic acid.

9. Which of the following is/are false?

(a) $MgFe_2O_4$ is a ferrite but $ZnFe_2O_4$ is not.

(b) Ferrites have spinel structure.

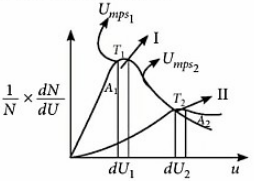
(c) Number of tetrahedral voids is four times the octahedral voids.

(d) If the radius of anion is double than that of cation, the crystalline solid has octahedral structure.

10. Following represents the Maxwell distribution curve for an ideal gas at two temperature T_1 and T_2. Which of the following option(s) are true?

A_1 = Area of small rectangle I

A_2 = Area of small rectangle II

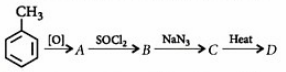


(a) Total area under the two curves is independent of moles of gas.

(b) If $dU_1 = fU_{mps_1}$ and $dU_2 = fU_{mps_2}$ then $A_1 = A_2$.

(c) $T_1 > T_2$ and hence higher the temperature, sharper the curve.

(d) The fraction of molecules having speed = U_{mps} decreases as temperature increases.

11. 

In the given sequence of reactions, is/are

(a) primary amine

(b) an amide

(c) phenyl isocyanate

(d) chain lengthened hydrocarbon.

12. A mixture of salts ($Na_2SO_3 + K_2Cr_2O_7$) in a test tube is treated with dil. H_2SO_4 and resulting gas is passed through lime water. Which of the following observations is/are correct about this test?

(a) Solution in test tube becomes green and lime water turns milky.

(b) Solution in test tube is colourless and lime water turns milky.

(c) Solution in test tube becomes green and lime water remains clear.

(d) Solution in test tube remains clear and lime water also remain clear.

Section 3 (Maximum Marks : 24)

- *This section contains SIX (06) questions. The answer to each question is a NUMERICAL VALUE.*
- *For each question, enter the correct numerical value of the answer using the mouse and the on-screen virtual numeric keypad in the place designated to enter the answer. If the numerical value has more than two decimal places, truncate/round-off the value to TWO decimal places.*
- *Answer to each question will be evaluated according to the following marking scheme :*

Full Marks : +4 *If ONLY the correct numerical value is entered.*

Zero Marks : 0 *In all other cases.*

13. An organic liquid *A*, (immiscible with water) when boiled together with water, the boiling point is 90°C at which the partial vapour pressure of water is 526 mm Hg. The atmospheric pressure is 736 mm Hg. The weight ratio of the liquid and water collected is 2.5 : 1. The molecular weight of the liquid is _____.

14. 18 mL of iodine and 25 mL of hydrogen when heated in a closed container, produced 30.8 mL of HI at equilibrium. The degree of dissociation of HI at the same temperature is _____.

15. A definite amount of $BaCl_2$ was dissolved in HCl solution of unknown normality. 20 mL of this solution was treated with 21.4 mL of N/10 NaOH for complete neutralisation. Further 20 mL of solution was added to 50 mL of N/10 Na_2CO_3 and the precipitate was filtered off. The filtrate reacted with 10.5 mL of 0.8 N/10 H_2SO_4 using phenolphthalein as an indicator. The sum of strengths (in g litre^{-1}) of $BaCl_2$ and HCl in mixture is _____.

16. For the decomposition of N_2O_5 at 127°C, *i.e.*, $N_2O_{5(g)} \rightarrow N_2O_{4(g)} + \frac{1}{2}O_{2(g)}$, if the initial pressure is 114 mm Hg and after 25 minutes of the reaction, total pressure of the gaseous mixture is 133 mm Hg, the average rate of reaction is 1×10^{-x} mol L^{-1} s^{-1}. The value of x is _____.

17. A metal weighing 0.43 g was dissolved in 50 mL of 1N H_2SO_4. The unreacted H_2SO_4 required 14.2 mL of 1N NaOH for neutralisation. The equivalent weight of the metal is _____.

18. 1 g of Ra^{226} is placed in an evacuated tube whose volume is 5 cc and then sealed. Assuming that each Ra nucleus emits four α-particles and all the particles are retained in the tube, pressure developed inside the tube at 27°C after 1590 years will be ($t_{1/2}$ for Ra is 1590 years) _____.

PAPER - II

Section 1 (Maximum Marks : 18)

- *This section contains SIX (06) questions.*
- *The answer to each question is a SINGLE DIGIT INTEGER ranging from 0 to 9, BOTH INCLUSIVE.*
- *For each question, enter the correct integer corresponding to the answer using the mouse and the on-screen virtual numeric keypad in the place designated to enter the answer.*
- *Answer to each question will be evaluated according to the following marking scheme :*

Full Marks : +3 *If ONLY the correct integer is entered.*

Zero Marks : 0 *If the question is unanswered;*

Negative Marks : –1 *In all other cases.*

1. Analysis shows that a metal oxide has the empirical formula $M_{0.97}O_{1.00}$ where, M is present in +2 and +3 oxidation states. The percentage of M present as M^{3+} is _____.

2. The value of x obtained when H—O—O bond angle in H_2O_2 is subtracted from 100.
i.e., x = 100 – (H—O—O bond angle) is _____.

3. A certain mass of a substance when dissolved in 100 g C_6H_6 lowers the freezing point by 1.28°C. The same mass of solute dissolved in 100 g of water lowers the freezing point by 1.40°C. If the substance has normal molecular mass in benzene and is completely dissociated in water, into how many ions does it dissociate in water. K_1 for H_2O and C_6H_6 are 1.86 and 5.12 Kmol^{-1} kg respectively.

4. A solid has a structure in which X atoms are located at cubic corners of unit cell. O atoms are at the edge centers and Y atoms at cube center.
Then the formula of compound is $X_aY_bO_c$
If two atoms of O are missing from any of two edge centers per unit cell, then the molecular formula is $X_xY_yZ_z$.
Then, find the value of $(x + y + z) - (a + b + c)$.

5. A very small amount of radioactive isotope of ^{213}Pb was mixed with a non-radioactive lead salt containing 0.01g of Pb (atomic mass 207). The

whole lead was brought into solution and lead chromate was precipitated by addition of a soluble chromate. Evaporation of 10 cm^3 of the supernatant liquid gave a residue having a radioactivity 1/24000 of that of the original quantity of ^{213}Pb. If the solubility of lead chromate is $x \times 10^{-7}$ mol dm^{-3}, then value of x is _____.

6. Same quantity of electricity being used to liberate iodine (at anode) and a metal (at cathode). The mass of metal liberated at cathode is 0.617 g and the liberated iodine completely reduced by 46.3 mL of 0.124 M sodium thiosulphate solution. If the equivalent weight of metal is $100 + x + 0.47$, then the value of x is _____.

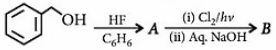
Section 2 (Maximum Marks : 24)

- *This section contains SIX (06) questions.*
- *Each question has FOUR options. ONE OR MORE THAN ONE of these four option(s) is (are) correct answer(s).*
- *For each question, choose the option(s) corresponding to (all) the correct answer(s).*
- *Answer to each will be evaluated according to the following marking scheme :*

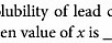
Full Marks :	*+4*	*If only (all) the correct option(s) is (are) chosen;*
Partial Marks :	*+3*	*If all the four options are correct but ONLY three options are chosen;*
Partial Marks :	*+2*	*If three or more options are correct but ONLY two options are chosen, and both of which are correct;*
Partial Marks :	*+1*	*If two or more options are correct but ONLY one option is chosen and it is a correct option;*
Zero Marks :	*0*	*If none of the options is chosen (i.e., the question is unanswered);*
Negative Marks :	*–2*	*In all other cases.*

7. Two bulbs A and B contains 16 g O_2 and 16 g O_3 respectively. Which of following the statement(s) is/are true?
   (a) Both bulbs contain same number of atoms.
   (b) Both bulbs contain different number of atoms.
   (c) Both bulbs contain same number of molecules.
   (d) Bulb a contains $N_A/2$ molecules while bulb B contains $N_A/3$ molecules (N_A = Avogadro's number).

8. In the given reaction sequence,



The compound 'B' is

(a) 
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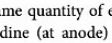
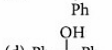
(c) 
(d) 

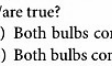
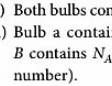
9. Which of the following is/are not true?
   (a) The most radioactive element present in pitchblende is uranium.
   (b) P-32 is used for the treatment of leukaemia.
   (c) CO_2 present in the air contains C – 12 only.
   (d) Emission of γ - rays changes the mass number but not atomic number.

10. When K_2CrO_4 is added to $CuSO_4$ solution, there is the formation of $CuCrO_4$ as well as $CuCr_2O_7$. Formation of $CuCr_2O_7$ is/are due to
    (a) basic nature of $CuSO_4$ solution which converts CrO_4^{2-} to $Cr_2O_7^{2-}$
    (b) acidic nature of $CuSO_4$ solution which converts CrO_4^{2-} to $Cr_2O_7^{2-}$
    (c) $CuSO_4$ has the typical property of converting $CuCrO_4$ formed to $CuCr_2O_7$
    (d) no $CuCr_2O_7$ is formed.

11. Assuming complete dissociation, which of the following aqueous solution(s) will have the same pH value.
    (a) 100 mL of 0.01 M HCl
    (b) 100 mL of 0.01 M H_2SO_4
    (c) 50 mL of 0.01 M HCl
    (d) Mixture of 50 mL of 0.02 M H_2SO_4 and 50 mL of 0.02 M NaOH

12. $\underset{\text{(Cyclopentanone)}}{C_5H_8O} \xrightarrow[\text{pH 9–10}]{HCN} (A) \xrightarrow[\text{Ether}]{LiAlH_4} (B) \xrightarrow[HCl]{NaNO_2} (C)$

The final product (C) in the above reaction is/are

(a) 
(b) 
(c) 
(d) 

Section 3 (Maximum Marks : 24)

- *This section contains SIX (06) questions. The answer to each question is a NUMERICAL VALUE.*
- *For each question, enter the correct numerical value of the answer using the mouse and the on-screen virtual numeric keypad in the place designated to enter the answer. If the numerical value has more than two decimal places, truncate/round-off the value to TWO decimal places.*
- *Answer to each question will be evaluated according to the following marking scheme:*

Full Marks : *+4 If ONLY the correct numerical value is entered;*

Zero Marks : *0 In all other cases.*

13. The half-life of ^{32}P is 14.3 days. The specific activity of a phosphorus containing specimen having 1.0 part per million ^{32}P (Atomic weight of P = 31) is_____.

14. Using the data provided, calculate the multiple bond energy (kJ mol^{-1}) of C ≡ C bond in C_2H_2. (Consider the bond energy of a C – H bond as 350 kJ mol^{-1}).

$2C_{(s)} + H_{2(g)} \longrightarrow C_2H_{2(g)}$; ΔH = 225 kJ mol^{-1}

$2C_{(s)} \longrightarrow 2C_{(g)}$; ΔH = 1410 kJ mol^{-1}

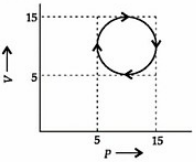
$H_{2(g)} \longrightarrow 2H_{(g)}$; ΔH = 330 kJ mol^{-1}

15. The equivalent conductance at infinite dilution of the salt MX is 160.84 ohm^{-1} cm^2 eq^{-1}. If the transport number of M^+ is 0.40, the ionic mobility of X^- in cm^2 V^{-1} s^{-1} is $n \times 10^{-3}$. The value of n is ___.

16. M_2O_x, a gaseous oxide, consists of 36.32% oxygen. In an experiment, the ratio of the rates of diffusion of carbon dioxide and that of oxide M_2O_x is found to be 4.7 : 4.6. The exact atomic weight of the element M is _____.

17. If excess of $AgNO_3$ solution is added to 100 mL of a 0.024 M solution of dichlorobis(ethylenediamine) cobalt(III) chloride, then $n \times 10^{-3}$ moles of AgCl will be precipitated. The value of n is _____.

18. What should be the amount of heat absorbed in this cyclic process?



SOLUTIONS

PAPER - I

1. (a): Number of atoms in 1 kg or 1000 g of ^{139}La

$$= \frac{1000\text{ g}}{139\text{ g}} \times 6 \times 10^{23} = \frac{6}{139} \times 10^{26}$$

$\therefore$ Number of radioactive ^{138}La atoms, N

= 0.1% of number of atoms of ^{139}La

$$= \frac{0.1}{100} \times \frac{6}{139} \times 10^{26} = \frac{6}{139} \times 10^{23}$$

Decay constant,

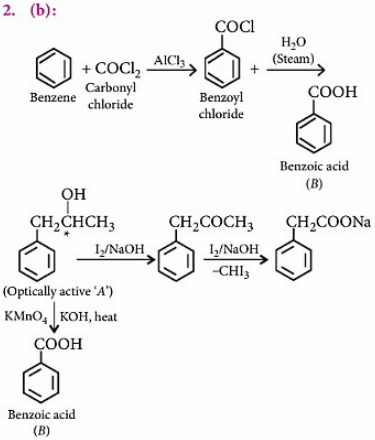
$$\lambda = \frac{0.693}{t_{1/2}} = \frac{0.693\text{ s}^{-1}}{1.1 \times 10^{10} \times 365 \times 24 \times (60)^2}$$

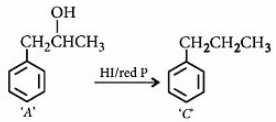
$\therefore$ Rate of decay, $R = -\frac{dN}{dt} = \lambda N$

$$= \frac{0.693}{1.1 \times 10^{10} \times 365 \times 24 \times 60 \times 60} \times \frac{6}{139} \times 10^{23}$$

$$= 8623\text{ s}^{-1}$$

2. (b):





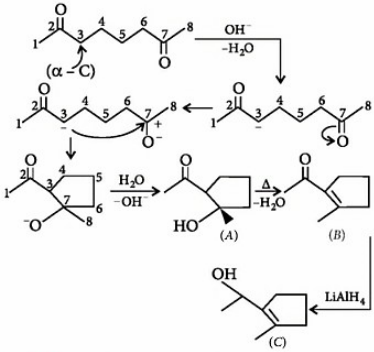
Molecular weight of '*C*' ($C_6H_5CH_2CH_2CH_3$) is $12 \times 9 + 12 = 108 + 12 = 120$ g mol^{-1}.

3. (c) : (c) is correct because it is conjugated diene and resonance stabilized.

(a) and (b) are not correct answers because they are isolated diene, therefore their heats of hydrogenation should be double *i.e.*, 252 kJ mol^{-1}.

(d) is not correct because it is cummulative diene.

4. (b): Given reactant, a diketone, can undergo internal aldol condensation reaction to form *A*.



5. (b): The colourless inorganic salt (*A*) is ammonium nitrate.

$$\underset{(A)}{NH_4NO_3} \xrightarrow{\Delta} \underset{(B)}{N_2O} + \underset{(C)}{2H_2O}$$

Product (*B*) *i.e.*, N_2O is a neutral gas, product (*C*) *i.e.*, H_2O is liquid and neutral to litmus.

$$\underset{(B)}{10N_2O} + P_4 \longrightarrow \underset{\text{(Dehydrating agent)}}{P_4O_{10}} + 10N_2$$

6. (d): Since, ethane is obtained by decarboxylation of an acid which is obtained by oxidation of a 1° alcohol, *i.e.*, *n*-propyl alcohol. Therefore, the acid must be propionic acid.

$$\underset{\substack{n\text{-Propyl alcohol}\\(D)}}{CH_3CH_2CH_2OH} \xrightarrow{[O]} \underset{\text{Propionic acid}}{CH_3CH_2COOH}$$

$$CH_3-CH_3 \xleftarrow[\text{(Decarboxylation)}]{\text{NaOH-CaO, }\Delta} CH_3CH_2COOH$$

Ethane

Since *n*-propyl alcohol (*D*) is obtained by the action of $NaNO_2$/HCl, on *B*, which, in turn, is obtained from alkyl bromide (*A*) by action of NH_3, therefore, (*A*) must be *n*-propyl bromide and (*B*) must be *n*-propylamine.

$$\underset{\substack{n\text{-Propyl bromide}\\(A)}}{CH_3CH_2CH_2Br} \xrightarrow[\text{Excess}]{NH_3} \underset{\substack{n\text{-Propylamine}\\(B)}}{CH_3CH_2CH_2NH_2}$$

$$CH_3CH_2CH_2OH \xleftarrow[HCl]{NaNO_2} CH_3CH_2CH_2NH_2$$

n-Propyl alcohol
(*D*)

Since (*C*) is obtained by the action of one equivalent of CH_3I on (*B*), therefore, (*C*) must be *n*-propylmethylamine and the compound (*E*) which it gives on treatment with $NaNO_2$/HCl must be its *N*-nitroso derivative.

$$\underset{(B)}{CH_3CH_2CH_2NH_2} \xrightarrow[-HI]{CH_3I} \underset{(C)}{CH_3CH_2CH_2-NH-CH_3}$$

$$CH_3CH_2CH_2-\underset{\underset{N=O}{|}}{N}-CH_3 \xleftarrow[HCl]{NaNO_2} CH_3CH_2CH_2-NH-CH_3$$

(*E*)

7. (a,c,d) : $\therefore\ M = \dfrac{28}{11.2} = 2.5$

$\therefore$ 1L contain 2.5 moles of H_2O_2

or $2.5 \times 34 = 85$ g H_2O_2

wt. of 1 litre solution = 265 g ($\because d = 265$ g/L)

$\therefore\ W_{H_2O} = 265 - 85 = 180$ g

or number of moles of $H_2O = \dfrac{180}{18} = 10$

$$X_{H_2O_2} = \frac{2.5}{2.5+10} = 0.2$$

$$\%\ \frac{w}{v} = \frac{2.5 \times 34}{1000} \times 100 = 8.5$$

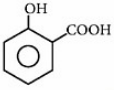
$$m = \frac{2.5}{180} \times 1000 = 13.88$$

8. (a, c) : $\ddot{C}N$ is a very good nucleophile. With this concept, KCN can react with 1° halide *i.e.*, CH_3CH_2Cl to give CH_3CH_2CN.

$$CH_3CH_2Cl + \overset{+}{K}\ddot{C}N \xrightarrow{S_N2} \underset{\text{(Major product)}}{CH_3CH_2CN}$$

$\ddot{C}N$ is a very good nucleophile and a very good leaving group, with this concept $\overset{+}{K}\ddot{C}N$ reacts with benzaldehyde to carry Benzoin condensation to give Ph—CH(OH)—C(=O)—Ph.

Chlorobenzene is inert to KCN because a partial double bond character is produced between chlorine and benzene ring due to resonance.

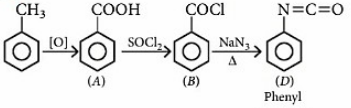


Salicylic acid does not react with KCN.

9. (a,c) : (a) is false because both are ferrites.
(c) is false because number of tetrahedral voids is double the number of octahedral voids.

10. (a,b,d)

11. (c) :



12. (c) : Na_2SO_3 with dil. H_2SO_4 gives SO_2 gas which reacts with $K_2Cr_2O_7$ to give a green solution due to $Cr_2(SO_4)_3$. Since whole of the gas is consumed, the lime water will remain clear.

$$Na_2SO_3 + H_2SO_4 \longrightarrow Na_2SO_4 + SO_2 + H_2O$$

$$K_2Cr_2O_7 + 3SO_2 + H_2SO_4 \longrightarrow \underset{\text{(green)}}{K_2SO_4 + Cr_2(SO_4)_3} + H_2O$$

13. (112.7) : At boiling point, $P_{\text{mixture}} = 736$ mm Hg
At boiling point, $p'_{H_2O} = 526$ mm Hg

$\therefore \quad p'_l = 736 - 526 = 210$ mm

Also, $p_l' = P_{\text{mixture}} \times x_{\text{(in vapour phase)}}$ ...(1)

Let a g of liquid and a g of water is collected or this is the amount of vapours at equilibrium.

Thus, wt. of liquid vapours $= \dfrac{2.5 \times a}{3.5}$

wt. of water vapours $= \dfrac{a}{3.5}$

Now, for liquid, from eq. (1)

$$210 = \frac{736 \times \dfrac{2.5a}{3.5 \times M}}{\dfrac{a}{3.5 \times 18} + \dfrac{2.5a}{3.5 \times M}} \qquad ...(2)$$

where M is mol. wt. of liquid.

For H_2O, from eq. (1),

$$526 = 736 \times \frac{\dfrac{a}{3.5 \times 18}}{\dfrac{a}{3.5 \times 18} + \dfrac{2.5a}{3.5 \times M}} \qquad ...(3)$$

Thus, from eqs. (2) and (3)

$$\frac{210}{526} = \frac{18 \times 2.5}{M}$$

$M = 112.7$ g mol^{-1}

14. (0.325) : As volume of the species is proportional to their concentration thus,

	H_2 +	I_2	$\rightleftharpoons$ 2HI
Initial volume	25	18	0
Volume at equilibrium	$(25 - x)$	$(18 - x)$	$2x (= 30.8)$
	$(25 - 15.4)$	$(18 - 15.4)$	30.8
	$= 9.6$	$= 2.6$	$\left(x = \dfrac{30.8}{2} = 15.4\right)$

$$K_c = \frac{[HI]^2}{[H_2][I_2]} = \frac{(30.8)^2}{9.6 \times 2.6} = 38.01$$

Now, if the dissociation of HI is carried out at the same temperature, degree of dissociation x', we have

	$2HI \rightleftharpoons$	H_2 +	I_2
Initial mole	1	0	0
Moles at equilibrium	$(1 - x')$	$\dfrac{x'}{2}$	$\dfrac{x'}{2}$

Equilibrium constant, $K_c' = \dfrac{1}{K_c} = \dfrac{1}{38.01}$

$$K_c' = \frac{\left(\dfrac{x'}{2}\right)\left(\dfrac{x'}{2}\right)}{(1 - x')^2} = \frac{1}{38.01} \Rightarrow x' = 0.325$$

15. (10.04) : Meq. of HCl added in $BaCl_2$ = Meq. of NaOH

$$20 \times N = 21.4 \times \frac{1}{10}$$

$$\therefore \quad N_{HCl} = \frac{21.4 \times 1}{10 \times 20} = 0.107$$

$\therefore$ Strength of HCl $= 0.107 \times 36.5 = 3.9055$ g litre^{-1}

Meq. of Na_2CO_3 added to 20 mL solution

$$= 50 \times \frac{1}{10} = 5$$

Meq. of Na_2CO_3 left after reaction with HCl and $BaCl_2$

= 2 × Meq. of H_2SO_4 using phenolphthalein indicator $= \frac{2 \times 10.5 \times 0.8}{10} = 1.68$

Meq. of Na_2CO_3 used for (HCl + $BaCl_2$) $= 5 - 1.68 = 3.32$

Meq. of HCl + Meq. of $BaCl_2 = 3.32$

$\therefore$ Meq. of $BaCl_2 = 3.32 -$ Meq. of HCl

$= 3.32 - 2.14$ (Meq. of HCl = 0.107×20) = 1.18

$\frac{w}{208/2} \times 1000 = 1.18$

Weight of $BaCl_2$ in 20 mL = 0.1227 g

$\therefore$ Strength of $BaCl_2 = 6.135$ g litre^{-1}

Sum of strength = 3.9055 + 6.135 $\Rightarrow$ 10.04 g litre^{-1}

16. (6):

	$N_2O_{5(g)} \longrightarrow$	$N_2O_{4(g)}$ +	$\frac{1}{2}O_{2(g)}$
Initial pressure	114 mm	0	0
After 25 min.	$114 - p$	p	$\frac{1}{2}p$

Total pressure = $(114 - p) + p + \frac{1}{2}p$

$= 114 + \frac{1}{2}p = 133$ mm (Given)

$\therefore \quad \frac{1}{2}p = 19 \quad$ or $\quad p = 38$ mm

To convert it into mol L^{-1}, apply $pV = nRT$, *i.e.*,

$\frac{n}{V} = \frac{p}{RT}$

$\therefore$ Decrease in molar concentration of N_2O_5

$= \frac{38/760 \text{ atm}}{0.0821 \text{ L atm K}^{-1}\text{mol}^{-1} \times 400 \text{ K}} = 0.0015 \text{ mol L}^{-1}$

$\therefore$ Average rate of reaction $= \frac{0.0015 \text{ mol L}^{-1}}{25 \times 60 \text{ s}}$

$= 1 \times 10^{-6}$ mol L^{-1}s^{-1}

17. (12.01) : Eq. of metal $= \frac{0.43}{E}$ (E is eq. wt. of metal)

$\therefore$ Meq. of metal $= \frac{0.43}{E} \times 1000 = \frac{430}{E}$

$\therefore$ Meq. of total H_2SO_4 solution $= 1 \times 50 = 50$

Meq. of H_2SO_4 reacted with metal = Meq. of the metal $= \frac{430}{E}$

$\therefore$ Meq. of unreacted $H_2SO_4 = \left(50 - \frac{430}{E}\right)$

Meq. of unreacted H_2SO_4 = Meq. of NaOH $= 1 \times 14.2$

$\therefore \quad 50 - \frac{430}{E} = 1 \times 14.2 \Rightarrow E = 12.01$

18. (43.59) : As $t_{1/2}$ = 1590 years, therefore, in 1590 years, half of the amount of Ra will disintegrate,

i.e., amount of Ra disintegrated = 0.5 g $= \frac{0.5}{226}$ mole

As each Ra nucleus produces four α-particles, therefore, helium produced $= \frac{0.5}{226} \times 4$ mole

$= 8.85 \times 10^{-3}$ mole

$PV = nRT \Rightarrow P = \frac{nRT}{V}$

$= \frac{(8.85 \times 10^{-3}\text{mole})(0.0821 \text{ L atm K}^{-1}\text{ mol}^{-1})(300 \text{ K})}{5 \times 10^{-3} \text{ L}}$

= 43.59 atm

PAPER - II

1. (6): The formula $M_{0.97}O_{1.00}$ shows that if there are 100 oxide ions, then there are 97 M atoms (present as M^{2+} and M^{3+}).

Charge on 100 O^{2-} ions = 200 units

Suppose M^{2+} present = x

Then, M^{3+} present = $97 - x$

Total charge on M^{2+} and $M^{3+} = 2x + 3(97 - x)$

$= 291 - x$

As metal oxide is neutral, total charge on cations = total charge on anions.

Hence, $291 - x = 200$ or $x = 91$

$\therefore \quad$ % of M as $M^{2+} = \frac{91}{97} \times 100 = 93.8\%$

% of M as $M^{3+} = 100 - 93.8 = 6.2\% \simeq 6\%$

2. (5): H—O—O bond angle in H_2O_2 is 94.8°. Therefore, $x = 100 - 94.8 = 5.2 \simeq 5$

3. (3): $\Delta T_f = \frac{1000 \times K_f \times w}{m \times W}$

For the solution in benzene using the data given

$1.28 = \frac{1000 \times 5.12 \times w}{m_N \times 100}$ (m_N = normal mol. mass) ...(i)

For the solution in water in which solute dissociate

$1.40 = \frac{1000 \times 1.86 \times w}{m_{exp} \times 100}$ ...(ii)

Dividing eq. (ii) by (i),

$i = \frac{m_N}{m_{exp.}} = \frac{1.40}{1.28} \times \frac{5.12}{1.86} = 3.01 = 3.0$

Now, suppose that formula of solute is

$$A_xB_y \rightleftharpoons xA^+ + yB^-$$

1 0 0

$(1-a)$ xa ya

$\therefore$ $i = 1 - a + xa + ya$

$\therefore$ $i = 3$ and $a = 1$ (Given that $a = 1$)

$\therefore$ No. of ions given $(x + y) = 3$

4. **(4):** First case, Number of X-atoms

$$= 8 \times \frac{1}{8} = 1/\text{unit cell}$$

Number of Y-atoms = 1/ unit cell

Number of O-atoms $= 12 \times \frac{1}{4} = 3/\text{unit cell}$

Formula is : $XYO_3 \Rightarrow X_aY_bO_c$

Second case, Number of O atoms missing from two edge centers per unit cell $= 2 \times \frac{1}{4} = \frac{1}{2} = /$ unit cell

Number of O atoms left $= 3 - \frac{1}{2} = 2.5/\text{unit cell}$

Formula is $XYO_{2.5} \Rightarrow X_2Y_2O_5 \Rightarrow X_xY_yO_z$

$\therefore$ The value of

$(x + y + z) - (a + b + c) = (2 + 2 + 5) - (1 + 1 + 3) = 4$

5. **(2):** Since the radioactivity of solution is $\frac{1}{24000}$ times to the original mixture, therefore the fraction of the radioactive lead obtained after evaporation of the supernatant liquid will be $\frac{1}{24000}$. Because almost whole amount of lead is precipitated in the form of $PbCrO_4$ an insoluble salt.

$\therefore$ Fraction of non-radioactive lead may also be taken $\frac{1}{24000}$.

The mass of non-radioactive lead obtained from 100 c.c. $= \frac{0.01}{24000}$

$\therefore$ Moles of non-radioactive lead obtained from 1L *i.e.*, solubility

$$= \frac{0.01}{207} \times \frac{1}{24000} \times \frac{1000}{10} = 2.0 \times 10^{-7} \text{ mol. dm}^{-3}$$

$\therefore$ $x = 2$

6. **(7):** $I_2 + 2e^- \longrightarrow 2I^-$

$2S_2O_3^{2-} \longrightarrow S_4O_6^{2-} + 2e^-$ $\left[\therefore E_{Na_2S_2O_3} = \frac{M}{1}\right]$

Eq. of metal = Eq. of I_2 = Eq. of hypo

$$\frac{0.617}{E} = \frac{46.3 \times 0.124}{1000}$$

$E = 107.47$; $107.47 = 100 + x + 0.47$

$\therefore$ $x = 7$

7. **(a, d) :** Number of O_2 atoms

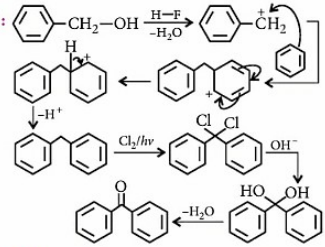
$$= \frac{16}{32} \times 2 \times N_A = 1 \times N_A$$

Number of O_3 atoms $= \frac{16}{48} \times 3 \times N_A = 1 \times N_A$

umber of O_2 molecules $= \frac{16}{32} \times N_A = \frac{1}{2} N_A$

Number of O_3 molecules $= \frac{16}{48} \times N_A = \frac{1}{3} N_A$

8. **(c):**



9. **(a, c, d) :** (a) is not true because most radioactive element present in pitchblende is radium.

(c) is not true because CO_2 in the air contains C-12 as well as C-14.

(d) is not true because emission of γ-rays neither changes mass number nor atomic number.

10. **(b):** $CuSO_4 + K_2CrO_4 \longrightarrow CuCrO_4\downarrow$

$CuSO_4 + 2H_2O \longrightarrow Cu(OH)_2 + H_2SO_4$

$2K_2CrO_4 + H_2SO_4 \longrightarrow K_2Cr_2O_7 + H_2O + K_2SO_4$

$CuSO_4 + K_2Cr_2O_7 \longrightarrow CuCr_2O_7\downarrow + K_2SO_4$

11. **(a, d) :** M. eq. of 0.01 M HCl

$$= \frac{0.01 \times 100}{1000} = 1 \times 10^{-3}; \quad \text{pH} = 3$$

M.eq of 0.02 M $H_2SO_4 = \frac{0.04 \times 50}{1000} = 2 \times 10^{-3}$

M.eq of 0.02 M NaOH $= \frac{0.02 \times 50}{1000} = 1 \times 10^{-3}$

Left $[H^+] = 2 \times 10^{-3} - 1 \times 10^{-3} = 1 \times 10^{-3}$

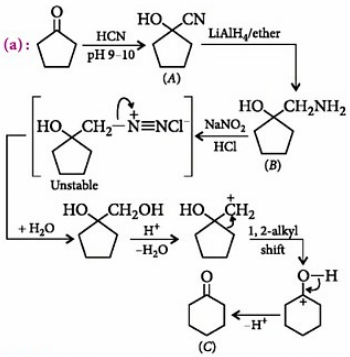
pH = 3

Quotable Quote

"Science is a way of thinking much more than it is a body of knowledge."

Carl Sagan

12. (a) :



13. (0.295) : The specific activity of a radioactive nucleus is its activity of disintegration rate per gram of specimen.

1 g of ^{31}P has $\frac{N}{31}$ atoms of ^{31}P

Thus, amount of ^{32}P in 1 g specimen = $\frac{N}{31\times10^6}$ atoms of ^{32}P. Thus, rate = $\lambda \cdot N$

$$= \frac{0.693}{14.3\times24\times60\times60}\times\frac{N}{31\times10^6}$$

$$= \frac{0.693\times6.023\times10^{23}}{14.3\times24\times60\times60\times31\times10^6}$$

Rate = 1.09×10^{10} dps per g specimen

or specific activity = 1.09×10^{10} dps per g

$$= \frac{1.09\times10^{10}}{3.7\times10^{10}} \text{ curie per g} = 0.295 \text{ Ci per g}$$

14. (815) : $2C_{(s)} + H_{2(g)} \longrightarrow C_2H_{2(g)}$; $\Delta H = 225$ kJ mol^{-1}

$2C_{(s)} + H_{2(g)} \longrightarrow C_2H_{2(g)}$; $\Delta H = 225$ kJ /mol

$2C_{(g)} + 2H_{(g)}$ $\quad -(2\varepsilon_{C-H} + \varepsilon_{C\equiv C})$

$\therefore \quad \Delta H = +1410 + 330 - (350\times2) - \varepsilon_{C\equiv C} = +225$

$\therefore \quad \varepsilon_{C\equiv C} = 1740 - 700 - 225 = 815$ kJ/mol

15. (1) : Ionic conductance of ion = Transport no. of that ion $\times$ Λ°_{eq} of strong electrolyte containing that ion = $(1 - 0.40)\times160.84 = 96.504$

$$\text{Ionic mobility} = \frac{\text{Ionic conductance}}{96{,}500}$$

$$= \frac{96.504}{96{,}500} = 1\times10^{-3} \text{ cm}^2\text{ V}^{-1}\text{ S}^{-1}$$

16. (14) : Equivalent weight of the element

$$= \frac{63.68}{36.32}\times8 = 14.03 \qquad \text{(Oxide formation method)}$$

Molecular weight of oxide can be calculated with the help of Graham's law of diffusion :

$$\frac{r_{CO_2}}{r_{M_2O_x}} = \sqrt{\frac{\text{Mol. wt. of } M_2O_x}{\text{Mol. wt. of } CO_2}}$$

or $\quad \frac{4.7}{4.6} = \sqrt{\frac{\text{Mol. wt. of } M_2O_x}{44}}$

$\Rightarrow$ Mol. wt. of $M_2O_x = 45.93$

Atomic weight of the element, $M = E\times x$

Therefore, $2(E\times x) + 16x = 45.93$

$x(2E + 16) = 45.93$

$$x = \frac{45.93}{2\times14.03 + 16} \approx 1$$

Atomic weight of the element,

$M = E\times x = E\times1 = 14.03 \approx 14$

17. (2.4) : Moles of the complex $= \frac{100\times0.024}{1000}$

$= 2.4\times10^{-3}$ mol

Complex is dichlorobis(ethylenediamine) cobalt(III) chloride.

$[Co(en)_2Cl_2]Cl + AgNO_3 \longrightarrow [Co(en)_2Cl_2]NO_3 + AgCl$

Since one mole of AgCl is formed per mole of complex.

Moles of AgCl precipitated = 2.4×10^{-3} mol

18. (78.6) : Cyclic process means, internal energy change = 0.

Now, finding the work done, we may calculate the heat absorbed.

$\therefore \quad \Delta U = \Delta q + \Delta W \Rightarrow \Delta q = -\Delta W$

Area under a curve gives the amount of work done.

$\therefore$ Here area of the circle is

$$\pi\cdot\left(\frac{15-5}{2}\right)^2 \text{ J} = \pi\cdot5^2 \text{ J} = 25\pi \text{ J} = 78.6 \text{ J}$$

◆◆

Monthly Test Drive CLASS XI ANSWER KEY

1. (d)	**2.** (d)	**3.** (b)	**4.** (d)	**5.** (c)
6. (c)	**7.** (c)	**8.** (a)	**9.** (c)	**10.** (a)
11. (c)	**12.** (a)	**13.** (d)	**14.** (a)	**15.** (d)
16. (d)	**17.** (c)	**18.** (d)	**19.** (d)	**20.** (b,d)
21. (a,b)	**22.** (a,b,c,d)	**23.** (a,c)	**24.** (5)	**25.** (4)
26. (4)	**27.** (d)	**28.** (d)	**29.** (a)	**30.** (b)

CONCEPT MAP
Class XI

ISOMERISM

The concept of isomerism illustrates the fundamental importance of molecular structure and shape in organic chemistry and the isomers play a vital role in biological processes.

Isomerism

Structural Isomerism

Same molecular formula and different bond pattern but different arrangement of atoms or groups of atoms within the molecules.

Chain Isomerism

Due to different arrangements of carbon atoms leading to linear and branched chains. For *e.g.*,

$H_3C-CH_2-CH_2-CH_3$, $H_3C-\underset{\displaystyle CH_3}{\underset{|}{CH}}-CH_3$

Butane; *Iso*-butane

Position Isomerism

Due to different positions of side chains, substituents, functional groups, double bonds, triple bonds, etc. on the parent chain. For *e.g.*,

$H_2C=CH-CH_2-CH_3$, $H_3C-CH=CH-CH_3$

But-1-ene; But-2-ene

Functional Isomerism

Due to presence of different functional groups. For *e.g.*,

H_3C-CH_2-OH, $H_3C-O-CH_3$

Ethyl alcohol; Dimethyl ether

Metamerism

Arises when different alkyl groups are attached to the same functional group. For *e.g.*,

$H_3C-CH_2-O-CH_2-CH_3$ Diethyl ether or Ethoxyethane

$H_3C-O-CH_2-CH_2-CH_3$ Methyl propyl ether or 1-Methoxypropane

Tautomerism

Tautomers have different functional groups and exist in dynamic equilibrium with each other due to a rapid interconversion from one form to another and the phenomenon is known as tautomerism. It is also called as desmotropism or kryptotropism or prototropy or allelo-tropism. For *e.g.*,

$H_3C-\overset{\displaystyle O}{\overset{\|}{C}}-CH_3 \rightleftharpoons H_3C-\underset{\displaystyle OH}{\underset{|}{C}}=CH_2$

Acetone (keto form); Prop-1-en-2-ol (enol form)

Keto-enol tautomerism

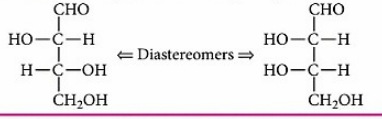
$H_3C-\overset{\displaystyle O}{\overset{\|}{N}}(\rightarrow O) \rightleftharpoons H_2C=\underset{\displaystyle O}{\underset{|}{N}}(\rightarrow OH)$

Nitromethane (nitro-form); (aci-form)

Nitro-aci tautomerism

Diastereoisomers

- Chiral molecules having different arrangement of groups or atoms at one or more (but not all) of the equivalent stereocentres.
- They are not mirror images and are non-superimposable.



Stereo Isomerism

Same molecular formula and bond pattern but different arrangement of atoms or groups of atoms in space.

Geometrical Isomerism

Same structural formula but differ in the spatial arrangement of atoms or groups of atoms about double bond (C=C or C=N or N=N).

Cis

Similar groups on the same side of the double bond

Trans

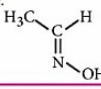
Similar groups on the different sides of the double bond

Syn

Two substituents (usually alkyl and hydroxyl) on the same side of the plane.

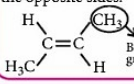
Anti

Two substituents (usually alkyl and hydroxyl) on the opposite side of the plane.



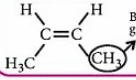
E

E is assigned to an isomer in which high priority atoms or groups are on the opposite sides.



Z

Z is assigned to an isomer in which high priority atoms or groups are on the same side.

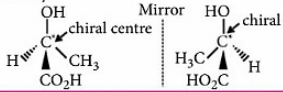


Optical Isomerism

Same molecular formula but differing only in the behaviour towards polarised light are called optical isomers and the phenomenon is called optical isomerism.

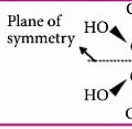
Enantiomers

- Chiral molecules with one or more stereo centres.
- Non-superimposable mirror images.
- No symmetry.



Meso Compounds

- Molecules with multiple stereocentres.
- Internal plane of symmetry thus, optically inactive.



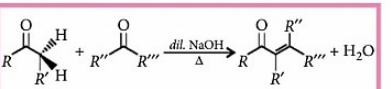
NAME REACTIONS

Apart from the convenience of being able to identify a given transformation by a simple name and assign credit to specific individual(s) the designation of a name reaction implies a high standard of utility, generality or uniqueness.

CONCEPT MAP Class XII

Aldol Condensation

Aldehydes/Ketones (atleast one α-H) $\xrightarrow[\Delta]{\text{Alkali}(dil.)}$ α, β-unsaturated aldehydes or ketones



Cannizzaro Reaction

Aldehydes (no α-H) $\xrightarrow{conc.\ NaOH}$ Carboxylic acid salt (Oxidised form) + Alcohol (Reduced form)

$$2RCHO \xrightarrow[\Delta]{conc.\ NaOH/KOH} RCH_2OH + RCOO^-Na^+$$

Clemmensen Reduction

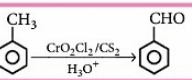
Aldehydes/Ketones $\xrightarrow[HCl]{Zn\text{-}Hg}$ Hydrocarbon(Alkanes)

$$R-COR' \xrightarrow[HCl]{Zn\text{-}Hg} \underset{R'}{\overset{R}{>}}CH_2$$

(where $R=R'$ or H)

Etard Reaction

Aromatic/Heterocyclic bound Methyl Group $\xrightarrow{[O]}$ Aromatic/Heterocyclic Aldehyde



Finkelstein Reaction

Alkyl Chlorides/Bromides $\xrightarrow[\text{Acetone(dry)}]{NaI}$ Alkyl Iodides

$$R-X \xrightarrow[\text{Acetone (dry)}]{NaI} R-I + NaX$$

(where X=Cl, Br)

Fittig Reaction

Aryl Halides $\xrightarrow[\text{or THF}]{\text{Na/Dry Ether}}$ Biaryls

Friedel-Crafts Alkylation

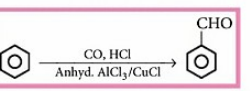
Aromatic Compound + $R-X \xrightarrow[\text{or } FeCl_3(anhyd.)]{AlCl_3(anhyd.)}$ Alkyl benzene

Friedel-Crafts Acylation

Aromatic Compound + $RCOCl/(RCO)_2O \xrightarrow{AlCl_3(anhyd.)}$ Acyl benzene

Gattermann-Koch Reaction

Benzene or its Derivatives $\xrightarrow[AlCl_3/CuCl\ (anhyd.)]{CO,\ HCl}$ Benzaldehyde or Substituted Benzaldehyde



Gabriel Phthalimide Reaction

Alkyl Halide $\xrightarrow[\text{2. } NH_2NH_2,\ \text{acid or base}]{\text{1. Phthalimide/base (}e.g.,\ KOH)}$ Primary Amine

$$R-X \xrightarrow[\text{2. } NH_2NH_2,\ \text{acid or base}]{\text{1. Phthalimide/base (}e.g.,\ KOH)} RNH_2$$

Gattermann Reaction

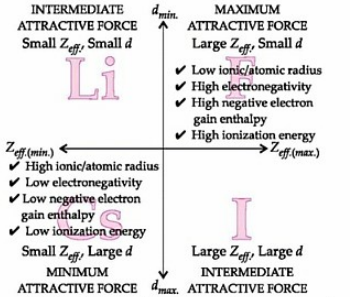
Benzenediazonium Chloride $\xrightarrow[\text{(where } X=Cl, Br)]{Cu/HX}$ Aryl Halide

$$ArN_2^+Cl^- \xrightarrow[\text{(where } X=Cl, Br)]{Cu/HX,\ \Delta} ArX + N_2$$

SOME IMPORTANT TRENDS OF INORGANIC CHEMISTRY

CAUSE OF PERIODICITY

Z-effective (the actual nuclear charge experienced by an electron) is important for understanding the periodic properties. It is calculated as $Z_{eff.} = Z - \sigma$ (σ is the screening constant which depends upon the number of inner electrons.)



where, d is the distance of outermost electrons from the nucleus.

GENERAL TRENDS (GROUPWISE)

s-BLOCK ELEMENTS

GROUP 1 (ALKALI METALS)

Basic strength: $LiOH < NaOH < KOH < RbOH < CsOH$

Stability: $Li_2CO_3 < Na_2CO_3 < K_2CO_3 < Rb_2CO_3 < Cs_2CO_3$

GROUP 2 (ALKALINE EARTH METALS)

Basic strength, Solubility and Thermal stability:

$Be(OH)_2 < Mg(OH)_2 < Ca(OH)_2 < Sr(OH)_2 < Ba(OH)_2$

Solubility: $BeCO_3 > MgCO_3 > CaCO_3 > SrCO_3 > BaCO_3$

$BeSO_4 > MgSO_4 > CaSO_4 > SrSO_4 > BaSO_4$ (Almost insoluble)

Stability: $BeCO_3 < MgCO_3 < CaCO_3 < SrCO_3 < BaCO_3$

$BeSO_4 < MgSO_4 < CaSO_4 < SrSO_4 < BaSO_4$

p-BLOCK ELEMENTS

GROUP 13 (BORON FAMILY)

Stability of +3 oxidation state:

$B^{3+} > Al^{3+} > Ga^{3+} > In^{3+} > Tl^{3+}$

Stability of +1 oxidation state: $B^{+} < Al^{+} < Ga^{+} < In^{+} < Tl^{+}$

Lewis acid character: $BX_3 > AlX_3 > GaX_3 > InX_3$ (where X is F, Cl, Br or I)

$BF_3 < BCl_3 < BBr_3 < BI_3$

Basic strength: $B_2O_3 < Al_2O_3 < Ga_2O_3 < In_2O_3 < Tl_2O_3$

$B(OH)_3 < Al(OH)_3 < Ga(OH)_3 < In(OH)_3 < Tl(OH)_3$

GROUP 14 (CARBON FAMILY)

Stability of +4 oxidation state: $Ge^{4+} > Sn^{4+} > Pb^{4+}$

Stability of +2 oxidation state: $Ge^{2+} < Sn^{2+} < Pb^{2+}$

Catenation tendency: $C >> Si > Ge \approx Sn >> Pb$

Acidic strength: $\underbrace{CO_2 > SiO_2}_{\text{Acidic}} > \underbrace{GeO_2}_{\text{Less acidic}} > \underbrace{SnO_2 > PbO_2}_{\text{Amphoteric}}$

GROUP 15 (NITROGEN FAMILY)

- **Hydrides:**

Bond angle, Thermal stability and Basic strength:

$NH_3 > PH_3 > AsH_3 > SbH_3 > BiH_3$

B.Pt.: $PH_3 < AsH_3 < NH_3 < SbH_3 < BiH_3$

M.Pt.: $PH_3 < AsH_3 < SbH_3 < NH_3$

Reducing nature: $NH_3 < PH_3 < AsH_3 < SbH_3 < BiH_3$

- **Halides:**

Bond angle: $PF_3 < PCl_3 < PBr_3 < PI_3$

Lewis acid strength: $PCl_3 > AsCl_3 > SbCl_3$

$PF_3 > PCl_3 > PBr_3 > PI_3$

GROUP 16 (OXYGEN FAMILY)

- **Hydrides:**

Bond angle and Thermal stability:

$H_2O > H_2S > H_2Se > H_2Te$

Volatility: $H_2S > H_2Se > H_2Te > H_2O$

Acidic strength and Reducing nature:

$H_2O < H_2S < H_2Se < H_2Te$

- **Halides : Stability:** $SF_6 > SeF_6 > TeF_6$

GROUP 17 (HALOGEN FAMILY)

Oxidizing power: $F_2 > Cl_2 > Br_2 > I_2$

- **Hydrogen halides:**

B.Pt. and M.Pt.: $HF > HCl < HBr < HI$

Dipole moment and Thermal stability:

$HF > HCl > HBr > HI$

Bond length, Acidic strength and Reducing nature:

$HF < HCl < HBr < HI$

- **Oxoacids of halogens:**

Acidic strength: $HClO < HClO_2 < HClO_3 < HClO_4$

Oxidizing power: $HClO > HClO_2 > HClO_3 > HClO_4$

GROUP 18 (NOBLE GASES)

M.Pt., B.Pt., Ease of liquefaction, Solubility, Adsorption and Polarizability: $He < Ne < Ar < Kr < Xe$

Thermal conductivity: $He > Ne > Ar > Kr > Xe$

d-BLOCK ELEMENTS

Acidic character: $MnO < Mn_2O_3 < Mn_2O_3 < MnO_2 < Mn_2O_7$

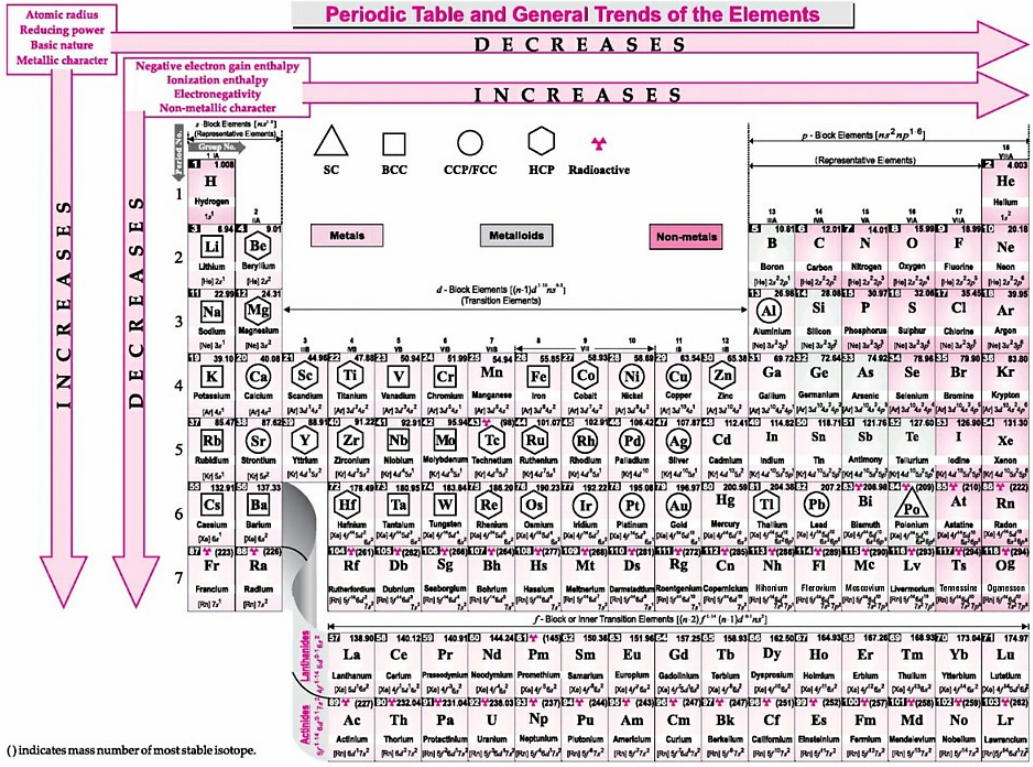
Ionic character: $MnO > Mn_3O_4 > Mn_2O_3 > MnO_2 > Mn_2O_7$

f-BLOCK ELEMENTS

$La(OH)_3$ to $Lu(OH)_3$: Basicity decreases

La^{3+} to Lu^{3+}: Tendency to form complexes increases

Periodic Table and General Trends of the Elements



GET SET GO for NEET

with exclusive and brain storming MCQs

Practicing these MCQs help to strengthen your concepts and give you extra edge in your NEET preparation

1. Arrange the following compounds in order of increasing dipole moment.

(I) Toluene (II) *m*-dichlorobenzene
(III) *o*-dichlorobenzene (IV) *p*-dichlorobenzene

(a) I < IV < II < III (b) IV < I < II < III
(c) IV < I < III < II (d) IV < II < I < III

2. 0.5 mole of each of H_2, SO_2 and CH_4 are kept in a container. A hole was made in the container. After 3 hours, the order of partial pressures in the container will be

(a) $p_{SO_2} > p_{CH_4} > p_{H_2}$ (b) $p_{H_2} > p_{SO_2} > p_{CH_4}$
(c) $p_{CH_4} > p_{SO_2} > p_{H_2}$ (d) $p_{H_2} > p_{CH_4} > p_{SO_2}$

3. The smog is essentially caused by presence of

(a) O_2 and O_3
(b) O_3 and N_2
(c) oxides of sulphur and nitrogen
(d) O_2 and N_2

4. $(CH_3)_2SiCl_2$ on hydrolysis will produce

(a) $(CH_3)_3Si(OH)$
(b) $(CH_3)_2Si=O$
(c) $-O-\left[(CH_3)_2Si-O-\right]_n$
(d) $(CH_3)_2SiCl(OH)$

5. Which set of quantum number is not possible?

(a) $n = 3, l = 2, m = 0, s = -\frac{1}{2}$

(b) $n = 3, l = 2, m = -2, s = -\frac{1}{2}$

(c) $n = 3, l = 3, m = -3, s = -\frac{1}{2}$

(d) $n = 3, l = 0, m = 0, s = -\frac{1}{2}$

6. The structure of *neo*-pentyl group in an organic compound is

(a) $CH_3-CH_2-CH_2-CH_2-CH_2-$

(b) $CH_3-CH_2-\underset{\displaystyle CH_3}{\underset{|}{CH}}-CH_2-$

(c) $CH_3-\underset{\displaystyle CH_3}{\underset{|}{\overset{\displaystyle CH_3}{\overset{|}{C}}}}-CH_2-$

(d) $CH_3-\underset{\displaystyle CH_3}{\underset{|}{CH}}-CH_2-CH_2-$

7. A real gas most closely approaches the behaviour of an ideal gas at
(a) 15 atm and 200 K (b) 1 atm and 273 K
(c) 0.5 atm and 500 K (d) 15 atm and 500 K.

8. Propyne on passing through red hot iron tube at 873 K, gives
(a) benzene
(b) anthracene
(c) 1, 4-dimethylbenzene
(d) 1, 3, 5-trimethylbenzene.

9. The correct order of first ionisation potential among the following elements Be, B, C, N, O is
(a) B < Be < C < O < N
(b) B < Be < C < N < O
(c) Be < B < C < N < O
(d) Be < B < C < O < N

10. If 10^{21} molecules are removed from 200 mg of CO_2, then the number of moles of CO_2 left are
(a) 2.85×10^{-3} (b) 28.8×10^{-3}
(c) 0.288×10^{-3} (d) 1.68×10^{-2}

11. In a compound C, H and N are present in 9 : 1 : 3.5 by weight. If molecular weight of the compound is 108, the molecular formula of compound is
(a) $C_2H_6N_2$ (b) C_3H_4N
(c) $C_6H_8N_2$ (d) $C_9H_{12}N_3$

12. The values of x, y and z in the following reaction are respectively

$$xMnO_4^- + yH^+ + zNO_2^- \longrightarrow xMn^{2+} + \frac{y}{2}H_2O + zNO_3^-$$

(a) 6, 2, 5 (b) 5, 2, 6
(c) 2, 5, 6 (d) 2, 6, 5

13. In the reaction,

$$4NH_{3(g)} + 5O_{2(g)} \longrightarrow 4NO_{(g)} + 6H_2O_{(g)}$$

when 1 mole of ammonia and 1 mole of O_2 are made to react to completion
(a) 1.0 mole of H_2O will be produced
(b) 1.0 mole of NO will be produced
(c) all the oxygen will be consumed
(d) all the ammonia will be consumed.

14. In the reaction, $HCN + H_2O \rightleftharpoons H_3O^+ + CN^-$, the conjugate acid-base pair is
(a) HCN, H_3O^+ (b) H_2O, CN^-
(c) CN^-, H_3O^+ (d) HCN, CN^-

15. The bond enthalpy of $H_{2(g)}$ is 436 kJ mol^{-1} and that of $N_{2(g)}$ is 941.3 kJ mol^{-1}. Calculate the average bond enthalpy of an N—H bond in ammonia if $\Delta H_f^o(NH_3) = -46.0$ kJ mol^{-1}.
(a) 443.67 kJ mol^{-1} (b) 474.33 kJ mol^{-1}
(c) 390.2 kJ mol^{-1} (d) 244.88 kJ mol^{-1}

SOLUTIONS

1. **(b)** : *p*-dichlorobenzene is non-polar. The two dipole vectors cancelling each others giving zero dipole moment (resultant). *o*-dichlorobenzene has greater dipole moment than meta isomer. Toluene is less polar then both *ortho* and *para* dichlorobenzene. Therefore, the correct order of increasing dipole moment is
p-dichlorobenzene < Toluene < *m*-dichlorobenzene < *o*-dichlorobenzene

2. **(a)** : Initially, partial pressures were equal. Now $r \propto \sqrt{1/d}$ or $\sqrt{1/M}$, therefore amounts diffused out at the same time will be $H_2 > CH_4 > SO_2$.
Amounts left will be $H_2 < CH_4 < SO_2$
Therefore, the correct order of partial pressure of the given gases in the container will be

$$P_{SO_2} > P_{CH_4} > P_{H_2}$$

3. **(c)** : Oxides of sulphur and nitrogen are major responsible factors for smog.

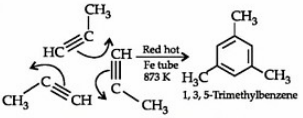
4. **(c)** : Due to very large size of Si atom than that of oxygen atom, it fails to form a π-bond and so the product of hydrolysis of $(CH_3)_2SiCl_2$ is a polymer *i.e.* $—O\text{-}\overset{(CH_3)_2}{\underset{|}{Si}}\text{-}O—_n$

5. **(c)** : If $n = 3$ then $l = 0$ to $n - 1$ and $m = -l$ to $+l$

6. **(c)**

7. **(c)** : A real gas approaches the behaviour of ideal gas when the pressure is low and the temperature is high.

8. **(d)** :



9. **(a)** : Due to the extra stability of half-filled *p*-orbitals of N, its first ionisation potential is higher than those of O and C. Further because of higher nuclear charge, first ionisation potential of C is higher than that of Be and B. Amongst Be and B, the first ionisation potential of Be is higher than that of B because in case of Be, an electron is to be removed from $2s^2$ orbital while in case of B, an electron is to removed from $2p^1$ orbital. Thus, the overall order is B < Be < C < O < N

10. **(a)** : 200 mg of $CO_2 = 200 \times 10^{-3} = 0.2$ g

44 g of $CO_2 \approx 6 \times 10^{23}$ molecules (approx)

$$0.2 \text{ g of } CO_2 = \frac{6\times10^{23}}{44} \times 0.2 = 0.0273 \times 10^{23}$$

$$= 2.73 \times 10^{21} \text{ molecules}$$

Now 10^{21} molecules are removed.

So, remaining molecules $= 2.73 \times 10^{21} - 10^{21}$

$= 10^{21}(2.73 - 1) = 1.73 \times 10^{21}$ molecules

Now, 6.023×10^{23} molecules = 1 mol

$$1.73 \times 10^{21} \text{ molecules} = \frac{1\times1.73\times10^{21}}{6.023\times10^{23}}$$

$$= 0.285 \times 10^{-2} = 2.85 \times 10^{-3}$$

11. **(c)** :

Wt. of C	:	Wt. of H	:	Wt. of N
9	:	1	:	3.5
Moles of C	:	Moles of H	:	Moles of N
$\frac{9}{12}$	:	$\frac{1}{1}$	:	$\frac{3.5}{14}$
0.75	:	1	:	0.25
3	:	4	:	1

$\therefore$ Empirical formula is C_3H_4N.

Empirical formula mass $= 3 \times 12 + 4 \times 1 + 14 = 54$

Molecular mass = 108

$$n = \frac{108}{54} = 2$$

Molecular formula = $(\text{Empirical formula})_n$

$= C_6H_8N_2$

12. **(d)** : $2MnO_4^- + 6H^+ + 5NO_2^- \longrightarrow 2Mn^{2+} + 3H_2O + 5NO_3^-$

13. **(c)** :

	$4NH_{3(g)}$	+	$5O_{2(g)}$	$\longrightarrow$	$4NO_{(g)}$	+	$6H_2O_{(g)}$
$t = 0$	1		1		0		0
$t = t$	$1 - 4x$		$1 - 5x$		$4x$		$6x$

Oxygen is limiting reagent.

So, $x = \frac{1}{5} = 0.2$ all oxygen consumed

Left $NH_3 = 1 - 4 \times 0.2 = 0.8$

14. **(c)** :

HCN	+	H_2O	$\rightleftharpoons$	H_3O^+	+	CN^-
Acid		Base		Conjugate acid		Conjugate base

15. **(c)** : Given,

$N_{2(g)} \longrightarrow 2N_{(g)}$; $\Delta H° = 941.3$ kJ mol^{-1} ...(i)

$H_{2(g)} \longrightarrow 2H_{(g)}$; $\Delta H° = 436.0$ kJ mol^{-1} ...(ii)

$\frac{1}{2}N_{2(g)} + \frac{3}{2}H_{2(g)} \longrightarrow NH_{3(g)}$;

$\Delta H° = -46.0$ kJ mol^{-1} ....(iii)

Multiply eqn. (i) by $\frac{1}{2}$ and (ii) by $\frac{3}{2}$ then add, we get,

$\frac{1}{2}N_{2(g)} + \frac{3}{2}H_{2(g)} \longrightarrow N_{(g)} + 3H_{(g)}$;

$\Delta H° = 941.3 \times \frac{1}{2} + 436.0 \times \frac{3}{2}$ ...(iv)

$= 470.65 + 654 = 1124.65$ kJ mol^{-1}

Now subtract eqn (iii) from eqn. (iv), we get

$NH_3 \longrightarrow N_{(g)} + 3H_{(g)}$; ...(v)

$\Delta H° = 1124.65 - (-46.0)$ kJ mol^{-1}

$= 1170.65$ kJ mol^{-1}

Since there are three N—H bonds in NH_3, the average bond enthalpy is obtained by dividing the value of $\Delta H°$ of eqn. (v) by 3.

Hence, $\Delta H_{N-H} = \frac{1170.65}{3} = 390.2$ kJ mol^{-1}

MONTHLY TEST DRIVE

This specially designed column enables students to self analyse their extent of understanding of specified chapters. Give yourself four marks for correct answer and deduct one mark for wrong answer. Self check table given at the end will help you to check your readiness.

Total Marks : 120 **The *s*-Block Elements | The *p*-Block Elements** **Time Taken : 60 Min.**

NEET

Only One Option Correct Type

1. The solubility of sulphates in water down the IIA group follows the order Be > Mg > Ca > Sr > Ba. This is due to
   (a) increase in melting point
   (b) increasing molecular mass
   (c) decreasing lattice energy
   (d) high heat of solvation of smaller ions.

2. Al_2O_3 on heating with carbon in an atmosphere of Cl_2 at high temperature produces
   (a) $Al + CO_2$ (b) $Al + CO_2 + NO$
   (c) $Al_4C_3 + CO_2$ (d) $AlCl_3 + CO$

3. Which of the following is false for alkali metals?
   (a) Li is strongest reducing agent.
   (b) Na is amphoteric in nature.
   (c) Li^+ is exceptionally small.
   (d) All alkali metals give blue coloured solutions in liquid ammonia.

4. On the basis of following
   $PbO_2 \rightarrow PbO$; $\Delta G_{298\,K} < 0$
   $SnO_2 \rightarrow SnO$; $\Delta G_{298\,K} > 0$
   most probable oxidation state of Pb and Sn will be
   (a) Pb^{4+}, Sn^{4+} (b) Pb^{4+}, Sn^{2+}
   (c) Pb^{2+}, Sn^{2+} (d) Pb^{2+}, Sn^{4+}

5. Which of the following alkaline earth metals has highest ionic mobility in an aqueous solution?
   (a) Be^{2+} (b) Ca^{2+} (c) Ba^{2+} (d) Mg^{2+}

6. The correct order of solubility of fluorides of alkaline earth metals is
   (a) $MgF_2 > BaF_2 > SrF_2 > CaF_2 > BeF_2$
   (b) $BeF_2 > MgF_2 > CaF_2 > SrF_2 > BaF_2$
   (c) $BeF_2 > BaF_2 > SrF_2 > CaF_2 > MgF_2$
   (d) none of these.

7. Boron trichloride on treatment with lithium aluminium hydride in diethyl ether gives
   (a) boric acid (b) borazine
   (c) diborane (d) borax.

8. Thermal stability of hydrides of first group elements follows the order
   (a) LiH > NaH > KH > RbH
   (b) LiH > KH > NaH > RbH
   (c) LiH > RbH > KH > NaH
   (d) RbH > KH > NaH > LiH

9. Among LiCl, $BeCl_2$, BCl_3 and CCl_4, the covalent bond character follows the order
   (a) $LiCl < BeCl_2 > BCl_3 > CCl_4$
   (b) $LiCl > BeCl_2 < BCl_3 < CCl_4$
   (c) $LiCl < BeCl_2 < BCl_3 < CCl_4$
   (d) $LiCl > BeCl_2 > BCl_3 > CCl_4$

10. In the given reaction,
    $Al_2(SO_4)_3 + NH_4OH \longrightarrow X$, X is
    (a) a white gelatinous precipitate
    (b) soluble in excess of NH_4OH
    (c) insoluble in excess of NaOH
    (d) acidic in nature.

11. In the replacement reaction,
    $\exists Cl + MF \longrightarrow \exists CF + MI$
    the reaction will be most favourable if M happens to be
    (a) Na (b) K (c) Rb (d) Li.

12. In curing cement plasters, water is sprinkled from time to time. This helps in
(a) developing interlocking needle like crystals of hydrated silicates
(b) hydrated sand gravel mixed with cement
(c) converting sand into silicic acid
(d) keeping it cool.

Assertion & Reason Type

Directions : In the following questions, a statement of assertion is followed by a statement of reason. Mark the correct choice as :
(a) If both assertion and reason are true and reason is the correct explanation of assertion.
(b) If both assertion and reason are true but reason is not the correct explanation of assertion.
(c) If assertion is true but reason is false.
(d) If both assertion and reason are false.

13. **Assertion :** Lewis acid character of boron trihalides decreases in the order: $BF_3 > BCl_3 > BBr_3 > BI_3$.
Reason : As electronegativity increases from F to I, Lewis acid character decreases from BF_3 to BI_3.

14. **Assertion :** The basic strength of alkali metal hydroxides increases as we go down the group from LiOH to CsOH.
Reason : The hydroxides of alkali metals have low ionization energies which decreases down the group.

15. **Assertion :** PbI_4 is stronger reducing agent than SnI_4.
Reason : Stability of higher oxidation states increases down the group from C to Pb.

JEE MAIN / JEE ADVANCED

Only One Option Correct Type

16. Which of the following statements is false?
(a) Strontium decomposes water readily than beryllium.
(b) Barium carbonate melts at a higher temperature than calcium carbonate.
(c) Barium hydroxide is more soluble in water than magnesium hydroxide.
(d) Beryllium hydroxide is more basic than barium hydroxide.

17. Which of the following statements about $H_3BO_3^{3-}$ is not correct?
(a) It has a layer structure in which planar BO_3^{3-} units are joined by hydrogen bonds.
(b) It does not act as proton donor but acts as a Lewis acid by accepting hydroxyl ion.
(c) It is a strong tribasic acid.
(d) It is prepared by acidifying an aqueous solution of borax.

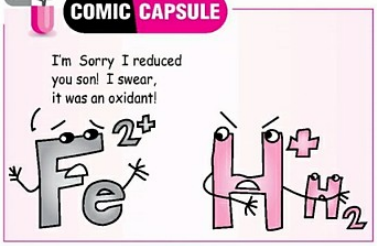
18. The correct order of the increasing *s*-character of the orbital of B which overlaps with the orbital of F to form B — F bond in BF_2^+, BF_3 and BF_4^- is
(a) $BF_2^+ < BF_4^- < BF_3$ (b) $BF_3 < BF_2^+ < BF_4^-$
(c) $BF_2^+ < BF_3 < BF_4^-$ (d) $BF_4^- < BF_3 < BF_2^+$

19. $CaCO_{3(s)} \xrightarrow{\text{Heat}} (A)_{(s)} + (B)_{(g)}$
$(A)_{(s)} \xrightarrow[\text{heat}]{\text{+ Carbon}} (C)_{(s)} + (D)_{(g)}$
$(C)_{(s)} + H_2O \longrightarrow (E)_{(g)}$
The compound $(E)_{(g)}$ is
(a) CO (b) CO_2 (c) CH_4 (d) C_2H_2

More than One Options Correct Type

20. With respect to graphite and diamond, which of the statements given are correct?
(a) Graphite is harder than diamond.
(b) Graphite has higher electrical conductivity than diamond.
(c) Graphite has higher thermal conductivity than diamond.
(d) Graphite has higher C — C bond order than diamond.

COMIC CAPSULE



21. Highly pure dilute solution of sodium in liquid ammonia
(a) shows blue colour
(b) exhibits electric conductivity
(c) produces sodium amide
(d) produces hydrogen gas.

22. Select the correct statements.
(a) BF_3 fumes strongly in moist air and is partially hydrolysed by excess of water.
(b) BF_3 is converted into the adducts $BF_3 \cdot H_2O$ and $BF_3 \cdot 2H_2O$ with small amounts of water at low temperature.
(c) H_3BO_3 is a weak acid but HBF_4 is a very strong acid.
(d) KBF_4 is sparingly soluble in water.

23. The composition of white lead is
(a) $2PbCO_3 \cdot Pb(OH)_2$
(b) $Pb(HCO_3)_2$
(c) $Pb(OH)_2 \cdot 2PbCO_3$
(d) $Pb(OH)_2 \cdot PbCO_3$

Integer / Numerical Value Type

24. Number of B — O — B bonds in borax is

25. One mole of lithium nitride is decomposed by H_2O and resultant solution is neutralised by HCl. Number of moles of HCl required is

26. Amongst the following, the maximum number of compounds showing basic nature is
B_2O_3, $B(OH)_3$, Al_2O_3, $Al(OH)_3$, Ga_2O_3, $Ga(OH)_3$, Tl_2O_3, Tl_2O, $Ti(OH)_3$, TlOH

Comprehension Type

'A' burns in nitrogen and forms 'B'
(Element) (Ionic Compound)

'B' + H_2O $\longrightarrow$ 'C' + 'D'
(Ionic compound)

'C'$_{(aq)}$ + CO_2 $\longrightarrow$ Milkiness appears

Consider the above information and answer the following questions.

27. The element 'A' is
(a) alkali metal (b) aluminium
(c) magnesium (d) calcium.

28. The milkiness that appears is due to
(a) $Ca(OH)_2$ (b) $Ca(HCO_3)_2$
(c) $Ba(HCO_3)_2$ (d) $CaCO_3$

Matrix Match Type

29. Match the compounds given in list I with their uses in list II and select the correct answer from the code given below the lists :

	List I		List II
P.	NaOH	1.	Glass
Q.	$Na_2S_2O_3$	2.	Germicide
R.	NaCN	3.	Antichlor
S.	Na_2CO_3	4.	Soap

	P	Q	R	S
(a)	4	3	2	1
(b)	3	4	1	2
(c)	2	3	4	1
(d)	1	2	3	4

30. Match the respective silicate (Column I) with its example (column II) and select the correct answer using the codes given below :

	Column I		Column II
P.	Orthosilicate	1.	Benitotite
Q.	Chain silicate	2.	Thortveitite
R.	Cyclic silicate	3.	Willemite
S.	Pyrosilicate	4.	Diopside

	P	Q	R	S
(a)	2	3	1	4
(b)	3	4	1	2
(c)	4	1	2	3
(d)	1	4	3	2

Keys are published in this issue. Search now! ☺

SELF CHECK

Check your score! If your score is

> 90%	EXCELLENT WORK !	You are well prepared to take the challenge of final exam.
90-75%	GOOD WORK !	You can score good in the final exam.
74-60%	SATISFACTORY !	You need to score more next time.
< 60%	NOT SATISFACTORY!	Revise thoroughly and strengthen your concepts.

No. of questions attempted .....
No. of questions correct .....
Marks scored in percentage .....

GET SET GO for JEE

with exclusive and brain storming MCQs

Practicing these MCQs help to strengthen your concepts and give you extra edge in your JEE preparation

1. The spin only magnetic moment (in B.M.) value of $[FeF_6]^{3-}$ and $[Co(CN)_6]^{3-}$ respectively are
   (a) 0 and 1.73 (b) 5.92 and 0
   (c) 4.47 and 1.73 (d) 5.92 and 3.87

2. Which of the following is arranged in order of increasing bond strength?
   (a) $Zn_2^{2+} < Hg_2^{2+} < Cd_2^{2+}$
   (b) $Cd_2^{2+} < Hg_2^{2+} < Zn_2^{2+}$
   (c) $Zn_2^{2+} < Cd_2^{2+} < Hg_2^{2+}$
   (d) $Hg_2^{2+} < Cd_2^{2+} < Zn_2^{2+}$

3. Chlorobenzene can be prepared by reacting aniline with
   (a) hydrochloric acid
   (b) cuprous chloride
   (c) chlorine in presence of anhydrous aluminium chloride
   (d) nitrous acid followed by heating with cuprous chloride.

4. Which of the following acts as an oxidising agent in chlorine water?
   (a) HCl (b) $HClO_2$
   (c) HOCl (d) None of these

5. Name the structure of silicate in which two oxygen atoms of $[SiO_4^{4-}]$ are shared.
   (a) Pyrosilicate
   (b) Sheet silicate
   (c) Linear chain silicate
   (d) Three dimensional silicate

6. If 3 faradays of electricity is passed through each of the solutions of $AgNO_3$, $CuSO_4$ and $AuCl_3$, the molar ratio of the cations deposited at the cathode will be
   (a) 1 : 1 : 1 (b) 1 : 2 : 3
   (c) 3 : 2 : 1 (d) 6 : 3 : 2

7. A crystalline solid has a cubic structure in which tungsten (W) atoms are located at the cube corners of the unit cell, oxygen atoms at the cube edges and sodium atoms at the cube centre. The molecular formula of the compound is
   (a) Na_2WO_3 (b) $NaWO_4$
   (c) $NaWO_3$ (d) Na_2WO_4

8. An ether is more volatile than an alcohol having the same molecular formula. This is due to
   (a) dipolar character of ethers
   (b) alcohols having resonance structures
   (c) intermolecular hydrogen bonding in ethers
   (d) intermolecular hydrogen bonding in alcohols.

9. Which of the following colligative properties can provide molar mass of proteins (or polymers or colloids) with greater precision?
   (a) Relative lowering of vapour pressure
   (b) Elevation in boiling point
   (c) Depression in freezing point
   (d) Osmotic pressure

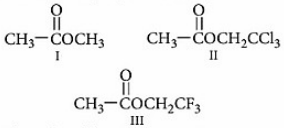
10. In the following reaction,
$$\text{Ethene} \xrightarrow[350-570\ \text{K, traces of } O_2]{1000-2000\ \text{atm}} A$$
A is
   (a) HDPE (b) LDPE
   (c) teflon (d) melamine.

11. When primary amine reacts with chloroform in ethanolic KOH then the product is
   (a) an isocyanide (b) an aldehyde
   (c) a cyanide (d) an alcohol.

12. When sulphur in the form of S_8 is heated at 900 K, the initial pressure of 1 atm falls by 29% at equilibrium. This is because of conversion of some S_8 into S_2. The value of equilibrium constant for this reaction is
   (a) 2.55 (b) 9.9×10^{-3}
   (c) 11×10^{-2} (d) 1.89

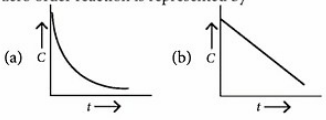
13. Benzoylacetonato beryllium exhibits the isomerism of the type of
   (a) structural (b) geometrical
   (c) optical (d) conformational.

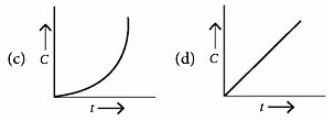
14. Consider the following compounds with regard to their reactivities towards nucleophilic acyl substitution by a given nucleophile.



The order of decreasing reactivity is
   (a) I > II > III (b) III > II > I
   (c) II > III > I (d) I > III > II

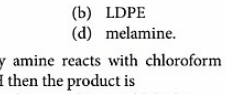
15. The plot between concentration versus time for a zero order reaction is represented by



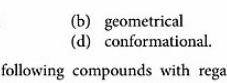


SOLUTIONS

1. **(b)** : The oxidation state of Fe in $[FeF_6]^{3-}$ is +3. Electronic configuration of Fe(Z = 26) is $[Ar]_{18}\ 3d^6 4s^2$.



Since F^- is a weak field ligand, no pairing takes place.
$\therefore$ The number of unpaired electrons in Fe^{3+} in $[FeF_6]^{3-}$ is 5.
The spin only magnetic moment value
$\mu = \sqrt{n(n+2)} = \sqrt{5 \times 7} = \sqrt{35} = 5.92$ BM
In $[Co(CN)_6]^{3-}$, Co exists as Co^{3+}
Electronic configuration of Co(Z = 27) is $[Ar]_{18}\ 3d^7\ 4s^2$.



In presence of strong field ligand (CN^-) pairing takes place.
$\therefore$ No. of unpaired electrons, $n = 0$
$\mu = \sqrt{n(n+2)} = 0$.

2. **(c)** : Due to poor shielding of 4f electrons, bond strength is maximum for Hg^+—Hg^+.

3. **(d)** : $C_6H_5NH_2 \xrightarrow[HCl]{HONO} C_6H_5\overset{+}{N}_2\bar{Cl} \xrightarrow{CuCl} C_6H_5Cl$

4. **(c)** : $Cl_2 + H_2O \longrightarrow HCl + HOCl$ (oxidising agent)
$HOCl \longrightarrow HCl + [O]$
HOCl can furnish nascent oxygen which is an oxidising agent.

5. **(c)**

6. **(d)** : $AgNO_3 : Ag^+ + e^- \rightarrow Ag$
1F 1 mol
$\therefore$ 3 faradays of electricity will deposit 3 moles of Ag.
$CuSO_4 : Cu^{2+} + 2e^- \rightarrow Cu$
2F 1 mol

$\therefore$ 3 faradays of electricity will deposit $\frac{3}{2}$ moles of Cu.

$AuCl_3 : Au^{3+} + 3e^- \rightarrow Au$

3F 1 mol

$\therefore$ 3 faradays of electricity will deposit 1 mole of Au.

Thus, Ag : Cu : Au = 3 : 3/2 : 1, *i.e.*, 6 : 3 : 2

7. **(c) :** Number of W-atoms (present at cube corners) per unit cell = $\frac{1}{8} \times 8 = 1$

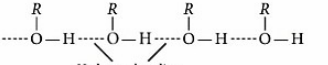
Number of O-atoms (present at cube edges) per unit cell = $\frac{1}{4} \times 12 = 3$

Number of Na-atoms (present at cube centre) per unit cell = 1

Thus, Na : W : O = 1 : 1 : 3

Thus, formula of the compound is $NaWO_3$.

8. **(d) :** The reason for the lesser volatility of alcohols than ethers is the intermolecular association of a large number of molecules due to hydrogen bonding as —OH group is highly polarised.



No such hydrogen bonding is present in ethers.

9. **(d) :** Molar mass of macromolecules (proteins, polymers or colloids, etc.) can be determined with greater precision by finding osmotic pressure because the magnitude of this colligative property is comparatively large even in dilute solutions.

10. **(b) :** Ethene $\xrightarrow[350-570\ K,\ traces\ of\ O_2]{1000-2000\ atm}$ LDPE

11. **(a) :** When a primary amine reacts with chloroform with ethanolic KOH, then a bad smell compound, isocyanide is formed. This is called carbylamine reaction and this reaction is used as a test of primary amines.

$RNH_2 + CHCl_3 + 3KOH \xrightarrow{\Delta} RNC + 3KCl + 3H_2O$

Primary amine Isocyanide

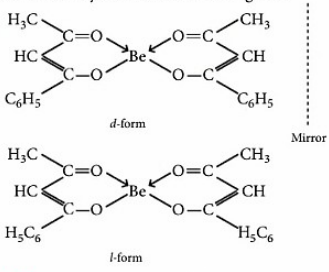
12. **(a) :**

	$S_{8(g)}$	$\rightleftharpoons$	$4S_{2(g)}$
Initially :	1 atm		0
At equilibrium :	$1-\frac{29}{100}$		0.29×4
	= 0.71 atm		= 1.16 atm

Equilibrium constant (K_p)

$$= \frac{(p_{S_2})^4}{(p_{S_8})} = \frac{(1.16)^4}{0.71} = 2.55$$

13. **(c) :** *bis*-(Benzoylacetonato)beryllium (II) exhibits optical isomerism as it is a tetrahedral complex and contains unsymmetrical bidentate ligands.



14. **(b) :** Higher the electron deficiency on carbonyl carbon atom, greater is the reactivity towards acyl substitution.

15. **(b) :** For zero order reaction, $k = \frac{1}{t}\{[A]_0 - [A]\}$

or $[A] = -kt + [A]_0$. Thus, plot of $[A]$ *vs* t is linear with –ve slope (= $-k$).

EXAM ALERT 2021

Exam	Date
JEE Main	27th to 30th April; 24th to 28th May
SRMJEEE	11th to 16th June
VITEEE	18th to 26th June
COMEDK (Engg.)	20th June
BITSAT	24th to 30th June
JEE Advanced	3rd July
Karnataka CET	7th, 8th, 9th July
WB JEE	11th July
NEET	1st August

CONCEPT BOOSTER

Organometallics and Coordination Chemistry

(An article of 18-Electron Rule)

Hello, Dear Students!! Hope you all are fit and fine. I am with another superb article where you will learn a different but important concept. I promise to give you high order conceptual articles in the subsequent months. I believe you all are practicing well for JEE MAIN & ADVANCED & NEET as well. You are getting ample opportunities this year. Use it. Good Luck!

*Arunava Sarkar

The name '18 electron rule' obviously reveals something about 'stability'. Actually, in a complex where the central metal atom appears to have the configuration of an inert gas tends to be more stable. Inert gas configuration is achieved either by transference or by sharing of electrons.

In a complex, the total number of electrons around the metal atom is called the effective atomic number (EAN). This is also called inert gas rule and according to this effective number of electrons in the $(n-1)d$, ns and np orbitals of a transition metal in its complex compound should be equal to $10 + 2 + 6 = 18$. So, what does it mean?

It implies, total number of electrons acquired by the metal through covalent or co-ordinate bonding with the ligands plus the number of original electrons in $(n-1)d$, ns and np orbitals prior to its complexation should be equal to 18 in any of the stable complexes of the metal. Overall, this statement is referred to as $18e^-$ rule.

There may by a question arising in your mind! Why $(n-1)d$ electrons are taken? This is because the inner $(n-1)d$ orbitals actively participate in chemical bonding.

Counting the effective atomic number of electrons

Following procedure can be followed :

- Count number of electrons in the valence shell {including $(n-1)d$}. If the complex contains positive charge, subtract electrons accordingly and if the complex contains negative charge, add electrons accordingly.
- Now check the number of electrons which the organic ligands formally contribute to the valence shell of the atom. Now check the following to understand the classification of ligands on the basis of number of electrons contributed by the ligand for the metal-carbon bond.

Classes of ligands with examples

(A) One electron ligand

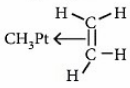
Some Grignard reagent can be taken into consideration like CH_3- in $CH_3-Mg-Br$

or $CH_3=CH-CH_2-$ in $CH_2=CH-CH_2-MgBr$

Similarly, C_6H_5 in $(C_6H_5)_3As$ is also an one-electron ligand.

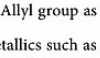
(B) Two electron ligands

Alkenes in *para* alkenyl organometallics like:



(C) Three electron ligands

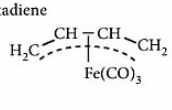
$H_2C-CH-CH_2 \Rightarrow$ Allyl group as in or you can see *para* allylic organometallics such as



*Institute of Chemistry (IOC)- Asansol, Durgapur, Dhanbad, Burdwan, Kolkata, Jamshedpur, Bokaro, Patna

(D) Four Electron ligands

Butadiene

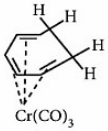


(E) Five electron ligands

Cyclopentadienyl group in paracyclo pentadienyl organometallics like

(F) Six electron ligands

Cyclooctatriene organometallics like

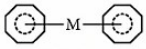


(G) Seven electron ligands

Tropilium *i.e.*, cycloheptatrienyl group in *para* tropilium organometallics like

(H) Eight electron ligands

Cyclooctatetraene in *para* cyclo-octatetraene organometallics such as

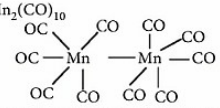


Now remember that CO is a special ligand. Each terminal CO contributes two electrons and each bridging CO contributes only one electron to the valence shell of the metal atom.

- Now, check number of electrons donated by conventional ligands to the valence shell of the metal atom.
- Now, also check number of electrons formally contributed to the valence shell of the metal by metal-metal bonds.

Each metal-metal bond contributes one electron to the valence shell.

e.g., (1) $Mn_2(CO)_{10}$



Number of electrons in the valence shell of the free metal atom = 7.

Number of electrons contributed by the ligands

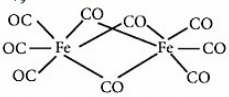
$= 2 \times 5 = 10$

Number of electrons contributed by metal-metal bond

$= 1$

$\therefore$ EAN = 7 + 10 + 1 = 18

(2) $Fe_2(CO)_9$



Number of electrons in the valence shell of the atom = 8

Number of electrons contributed by 3 CO bridges

$= (1 \times 3) = 3$

Number of electrons contributed by 3 CO conventional ligands = $(3 \times 2) = 6$

Number of electrons contributed by metal-metal bond

$= 1$

$\therefore$ EAN = (8 + 3 + 6 + 1) = 18

TEST YOURSELF

Q. The complex that does not obey the 18 electron rule is

(Given : Atomic number of Ti, Mn, Ta, Ir are 22, 25, 73, 77 respectively)

(a) $[Mn(SnPh_3)_2(CO)_4]^-$

(b) $[TaCl_3(PEt_3)_2(CHCMe_3)]$

(c) $[(\eta^5 - C_5H_5)Ir(CH_2)(PMe_3)]$

(d) $[(\eta^5 - C_5H_5)Ti(CO)_4]^-$

Ans. (b)

CBSE warm-up!

Exam on 18th May 2021

CLASS-XII

Practice questions for CBSE Exams as per the reduced syllabus, latest pattern and marking scheme issued by CBSE for the academic session 2020-21.

Practice Paper 2021

Time Allowed : 3 hours
Maximum Marks : 70

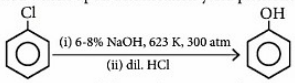
General Instructions : Read the following instructions carefully.

(a) There are 33 questions in this question paper. All questions are compulsory.
(b) Section A : Q. No. 1 to 16 are objective type questions. Q. No. 1 and 2 are passage based questions carrying 4 marks each while Q. No. 3 to 16 carry 1 mark each.
(c) Section B : Q. No. 17 to 25 are short answer questions and carry 2 marks each.
(d) Section C : Q. No. 26 to 30 are short answer questions and carry 3 marks each.
(e) Section D : Q. No. 31 to 33 are long answer questions carrying 5 marks each.
(f) There is no overall choice. However, internal choices have been provided.
(g) Use of calculators and log tables is not permitted.

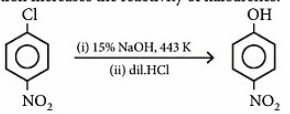
SECTION-A (OBJECTIVE TYPE)

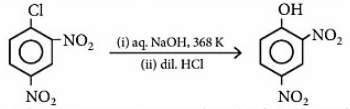
1. Read the passage given below and answer the following questions :

When haloarenes are heated with an aqueous solution of NaOH at 623 K and under 300 atmospheric pressure, sodium phenoxides are formed which upon acidification yield phenols.

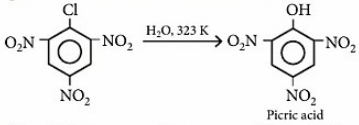


This process is called Dow's process. The presence of electron withdrawing group at *ortho* and *para* position increases the reactivity of haloarenes.





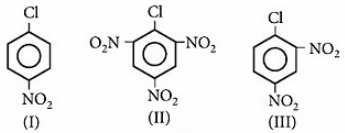
Only warm water is required in the formation of picric acid from 2, 4, 6 –trinitrochlorobenzene.



Picric acid

The following questions are multiple choice questions. Choose the most appropriate answer :

(i) The correct order of reactivity towards nucleophilic substitution reaction with CH_3ONa of the following compound is

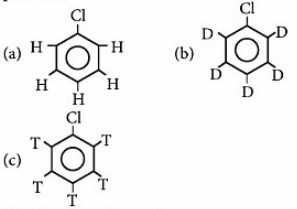


(I) (II) (III)

(a) I > II > III (b) III > II > I

(c) I > III > II (d) II > III > I

(ii) The most reactive compound towards the Dow's process is



(d) all are equally reactive.

(iii) Dow's process is used for the preparation of which of the following?

(a) Esters (b) Phenols

(c) Alcohols (d) Ethers

OR

Dow's process involves

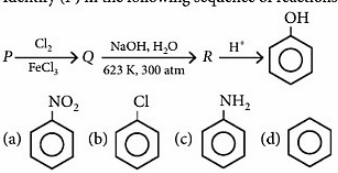
(a) electrophilic addition reaction

(b) nucleophilic addition reaction

(c) electrophilic substitution reaction

(d) nucleophilic substitution reaction.

(iv) Identify (*P*) in the following sequence of reactions :



2. Read the passage given below and answer the following questions :

In the gaseous state the hydrogen halides are essentially covalent but in aqueous solution they ionise.

$$HX + H_2O \rightarrow H_3O^+ + X^-$$

The aqueous solutions form azeotropic mixtures with maximum boiling points. Such solutions can be used as standards for volumetric analysis. In dilute aqueous solutions, HF is only slightly ionized, but HCl, HBr and HI are completely ionized. In poorer ionizing solvents such as methanol, ionisation is much less complete and HCl is less ionized than HI. The ΔH values for the dissociation of $HX_{(hydrated)}$ into $H^+_{(hydrated)}$ and $X^-_{(hydrated)}$ are negative. So the change is thermodynamically possible. HF is only slightly exothermic in aqueous solution whereas the others evolve a considerable amount of heat.

In these questions (Q. No. (i)-(iv)), a statement of assertion followed by a statement of reason is given. Choose the correct answer out of the following choices.

(a) Assertion and reason both are correct statements and reason is correct explanation for assertion.

(b) Assertion and reason both are correct statements but reason is not correct explanation for assertion.

(c) Assertion is correct statement but reason is wrong statement.

(d) Assertion is wrong statement but reason is correct statement.

(i) **Assertion :** HF is the strongest acid among the hydrogen halides.
Reason : HF has a greater electronegativity difference and more ionic character than the other hydrides.

(ii) **Assertion :** Reaction of conc. H_2SO_4 on NaBr and NaI does not give HBr and HI.
Reason : HBr and HI are oxidised by conc. H_2SO_4 to Br_2 and I_2.

(iii) **Assertion :** Heat evolved in neutralisation of $HF_{(aq)}$ (a weak acid), with $NaOH_{(aq)}$ is more than 13.7 kcal.
Reason : Some heat is used in the ionisation of weak acid.

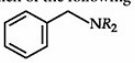
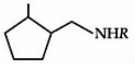
OR

Assertion : Reducing power of the hydrogen halides increases in the order: HI < HBr < HCl < HF.
Reason : Bond dissociation energies of the hydrogen halides increases in the order: HI < HBr < HCl < HF.

(iv) **Assertion :** Liquid HF has been used as a non-aqueous solvent.
Reason : HF is only very slightly ionized in water.

Following questions (Q. No. 3-11) are multiple choice questions carrying 1 mark each :

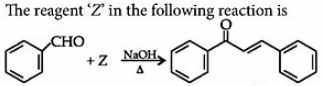
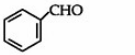
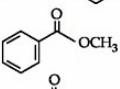
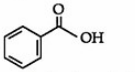
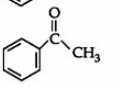
3. The vapour pressures of ethanol and methanol are 42.0 mm Hg and 88.5 mm Hg respectively. An ideal solution is formed at the same temperature by mixing 46.0 g of ethanol with 16.0 g of methanol. The mole fraction of methanol in the vapour phase is
(a) 0.334 (b) 0.662 (c) 0.513 (d) 0.483

4. Which of the following is 3° amine?
(a)  (b) 
(c)  (d) 

OR

Which of the following will not undergo Hinsberg's test?
(a) 1° amine (b) 2° amine
(c) 3° amine (d) Both (a) and (b)

5. A molecule contains atoms P and Q so that P occurs at the corners of the cube while Q at the face centre. The formula of the molecule can be
(a) PQ_3 (b) P_3Q (c) PQ_2 (d) P_2Q

6. The reagent 'Z' in the following reaction is

(a)  (b) 
(c)  (d) 

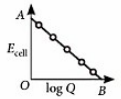
7. The equivalent conductivity of 0.05 N solution of a monobasic acid is 15.8 mho cm^2 eq^{-1}. If equivalent conductivity of the acid at infinite dilution is 350 mho cm^2 eq^{-1}, the dissociation constant of acid is
(a) 1.293×10^{-5} (b) 1.642×10^{-4}
(c) 1.019×10^{-4} (d) 1.392×10^{-5}

OR

$Zn + Cu^{2+}_{(aq)} \rightleftharpoons Cu + Zn^{2+}_{(aq)}$

Reaction quotient, $Q = \dfrac{[Zn^{2+}]}{[Cu^{2+}]}$

Variation of E_{cell} with log Q is of the type given in graph with OA = 1.10 V, E_{cell} will be 1.1591 V when



(a) $[Cu^{2+}]/[Zn^{2+}] = 0.1$ (b) $[Cu^{2+}]/[Zn^{2+}] = 0.01$
(c) $[Zn^{2+}]/[Cu^{2+}] = 0.01$ (d) $[Zn^{2+}]/[Cu^{2+}] = 0.1$

8. Amongst TiF_6^{2-}, CoF_6^{3-}, Cu_2Cl_2 and $NiCl_4^{2-}$ (At. nos. of Ti = 22, Co = 27, Cu = 29, Ni = 28). The colourless species are
(a) CoF_6^{3-} and $NiCl_4^{2-}$ (b) TiF_6^{2-} and CoF_6^{3-}
(c) Cu_2Cl_2 and $NiCl_4^{2-}$ (d) TiF_6^{2-} and Cu_2Cl_2

9. Arrange the following electrolytes in increasing order of coagulation power for As_2S_3 sol.

A_1	A_2	A_3	A_4
K_2SO_4	$CaCl_2$	Na_3PO_4	$AlCl_3$

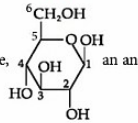
(a) $A_1 = A_3 < A_2 < A_4$ (b) $A_1 > A_2 > A_3 > A_4$
(c) $A_2 < A_4 < A_1 < A_2$ (d) $A_2 < A_3 < A_4 < A_1$

OR

Freundlich adsorption isotherm gives a straight line on plotting
(a) $\dfrac{x}{m}$ vs P (b) $\log\left(\dfrac{x}{m}\right)$ vs P
(c) $\log\left(\dfrac{x}{m}\right)$ $vs \log P$ (d) $\dfrac{x}{m}$ $vs \dfrac{1}{P}$

10. Product formed on oxidation of gluconic acid with nitric acid is
(a) n-hexane (b) saccharic acid
(c) sucrose (d) cellulose.

OR

In the structure,  an anomeric carbon is
(a) 1 (b) 2 (c) 3 (d) 4

11. E° values for Ti^{2+}/Ti, V^{2+}/V, Mn^{3+}/Mn^{2+}, V^{3+}/V^{2+} and Co^{3+}/Co^{2+} are – 1.63 V, – 1.18 V, +1.57 V, – 0.26 V and + 1.97 V respectively.

Identify the incorrect statement.

(a) Ti^{2+} and V^{2+} are strongest reducing agents and liberate hydrogen gas from dilute acids.

(b) Mn^{3+} and Co^{3+} are strongest oxidising agents in aqueous solution.

(c) Mn^{2+} is very stable due to the stable d^5 configuration.

(d) V^{2+} is less stable than V^{3+}.

In the following questions (Q. No. 12 - 16) a statement of assertion followed by a statement of reason is given. Choose the correct answer out of the following choices.

(a) Assertion and reason both are correct statements and reason is correct explanation for assertion.

(b) Assertion and reason both are correct statements but reason is not correct explanation for assertion.

(c) Assertion is correct statement but reason is wrong statement.

(d) Assertion is wrong statement but reason is correct statement.

12. **Assertion :** Decrease in the vapour pressure of water by adding 1.0 mol of sucrose to one kg of water is nearly similar to that produced by adding 1.0 mol of urea to the same quantity of water at the same temperature.
Reason : Decrease in the vapour pressure of solvent depends on the quantity of non-volatile solute present in the fixed amount of solvent, irrespective of its nature.

13. **Assertion :** For the first order reaction, half-life period is expressed as $t_{1/2} = \frac{2.303}{k}\log 2$
Reason : The half-life time of a first order reaction is not always constant and it depends upon the initial concentration of reactants.

14. **Assertion :** The second ionization energies of ${}_{23}V$, ${}_{24}Cr$ and ${}_{25}Mn$ are in the order V < Cr < Mn.
Reason : In general, ionization energies show a regular increase along a period with increase in atomic number.

15. **Assertion :** Addition of HCN to carbonyl compounds gives cyanohydrins.
Reason : Pure HCN reacts with aldehydes and ketones.

16. **Assertion :** Boiling point of propan-l-ol (370 K) is higher than that of methoxyethane (281 K) though they have same molecular mass (60).
Reason : The higher boiling points of alcohols are mainly due to the presence of intermolecular hydrogen bonding in them which is lacking in ethers.

OR

Assertion : Phenol undergoes Kolbe reaction whereas ethanol does not.
Reason : Phenoxide ion is more basic than ethoxide ion.

SECTION-B

The following questions, Q. No. 17 – 25 are short answer type and carry 2 marks each.

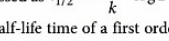
17. Vapour pressure of chloroform ($CHCl_3$) and dichloromethane (CH_2Cl_2) at 298 K are 200 mm Hg and 415 mm Hg respectively. Calculate the vapour pressure of the solution prepared by mixing 25.5 g of $CHCl_3$ and 40 g of CH_2Cl_2 at 298 K.

18. Give reasons :
(i) Mn shows the highest oxidation state of +7 with oxygen but with fluorine it shows the highest oxidation state of +4.
(ii) Transition metals show variable oxidation states.

OR

How would you account for the following :
(i) Transition elements have high enthalpies of atomisation.
(ii) Transition metals and their compounds are found to be good catalysts in many processes?

19. Draw the structures of the following molecules :
(i) $H_2S_2O_8$ (ii) IF_7

20. (a) Write the product of the following reactions :
(i) 
(ii) $CH_3COOH \xrightarrow{Cl_2/P}$

21. Show that in a first order reaction, time required for completion of 99.9% is 10 times of half-life ($t_{1/2}$) of the reaction.

OR

Show that in a first order reaction, time required for 99% completion is twice the time required for the completion of 90% reaction.

22. (i) Which alkyl halide from the following pair is chiral and undergoes faster S_N2 reaction?
(a)  (b) 

(ii) Out of S_N1 and S_N2, which reaction occurs with
(a) inversion of configuration
(b) racemisation

23. Explain what is observed :
(i) when a beam of light is passed through a colloidal solution.
(ii) an electrolyte is added to hydrated ferric oxide sol.

24. What are essential and non-essential amino acids? Give two examples of each type.

25. Write the IUPAC names of the following compounds :
(i) $CH_3-N(CH_3)-CH_2-CH_2-CH_3$
(ii) 
(iii) 
(iv) 

OR

Write the following reactions :
(i) Gabriel phthalimide synthesis
(ii) Hoffmann bromamide reaction

SECTION-C

Q. No. 26 - 30 are short answer type II carrying 3 marks each.

26. Write the mechanism for the preparation of ethene from ethanol.

OR

(i) Write the mechanism of the following reaction:
$CH_3CH_2OH \xrightarrow{HBr} CH_3CH_2Br + H_2O$
(ii) Write the equation involved in Reimer—Tiemann reaction.

27. The thermal decomposition of HCO_2H is a first order reaction with a rate constant of $2.4 \times 10^{-3}\ s^{-1}$ at a certain temperature. Calculate how long will it take for three-fourth of initial quantity of HCO_2H to decompose. (log 0.25 = –0.6021)

28. Do the following conversions :
(i) Aniline to *p*-bromoaniline
(ii) Ethanamine to ethanol
(iii) Methanamine to methyl isocyanide

29. Answer the following questions with reasons.
(i) Which element of the first transition series has highest second ionisation enthalpy?
(ii) Which element of the first transition series has highest third ionisation enthalpy?
(iii) Which element of the first transition series has lowest enthalpy of atomisation?

OR

(i) Name the element of 3*d* transition series which shows maximum number of oxidation states. Why does it show so?
(ii) Which transition metal of 3*d* series has positive $E^\circ_{(M^{2+}/M)}$ value and why?
(iii) Out of Cr^{3+} and Mn^{3+}, which is stronger oxidizing agent and why?

30. (i) Sodium has a *bcc* structure with nearest neighbour distance 365.9 pm. Calculate its density. (Atomic mass of sodium = 23)
(ii) If NaCl is doped with 10^{-3} mol % of $SrCl_2$, what is the concentration of cation vacancies?

SECTION-D

Q. No. 31 - 33 are long answer type carrying 5 marks each.

31. (i) (a) Carboxylic acid is a stronger acid than phenol. Why?
(b) Arrange the following compounds in decreasing order of their acidic strength : C_6H_5COOH, CH_3COOH, HCOOH
(ii) An organic compound (*A*) having molecular formula ($C_8H_{16}O_2$) was hydrolysed with dilute sulphuric acid to give two compounds (*B*) and (*C*). Oxidation of (*C*) with chromic acid produced (*B*). (*C*) on dehydration gives but-1-ene. Write equations for the reactions involved.

OR

(i) How will you prepare the following compounds starting with benzene :
(a) Benzaldehyde (b) Acetophenone?
(ii) Write the following conversions in not more than two steps :
(a) Benzaldehdye to α-hydroxyphenylacetic acid
(b) Bromobenzene to 1-phenylethanol
(c) Benzaldehyde to benzophenone

32. (i) Resistance of a conductivity cell filled with 0.1 mol L^{-1} KCl solution is 100 Ω. If the resistance of the same cell when filled with 0.02 mol L^{-1} KCl solution is 520 Ω, calculate the conductivity and molar conductivity of 0.02 mol L^{-1} KCl solution. The conductivity of 0.1 mol L^{-1} KCl solution is $1.29 \times 10^{-2}\ \Omega^{-1}\ cm^{-1}$.

(ii) Calculate the emf of following cell at 298 K:
$Mg_{(s)} \mid Mg^{2+}(0.1\ M) \parallel Cu^{2+}(0.01) \mid Cu_{(s)}$
[Given : $E^{\circ}_{cell} = +2.71$ V, $1\ F = 96500\ C\ mol^{-1}$]

OR

An excess of liquid mercury is added to an acidified solution of 1.0×10^{-3} M Fe^{3+}. It is found that 5% of Fe^{3+} remains at equilibrium at 25°C. Calculate $E^{\circ}_{(Hg_2^{2+}/Hg)}$ assuming that the only reaction that occurs is

$2Hg + 2Fe^{3+} \longrightarrow Hg_2^{2+} + 2Fe^{2+}$

(Given : $E^{\circ}_{(Fe^{3+}/Fe^{2+})} = 0.77$ V)

33. (i) Using crystal field theory, draw energy level diagram, write electronic configuration of the central metal atom/ion and determine the magnetic moment value in the following :
(a) $[CoF_6]^{3-}$, **(b)** $[FeF_6]^{3-}$, **(c)** $[Fe(CN)_6]^{4-}$

(ii) $FeSO_4$ solution mixed with $(NH_4)_2SO_4$ solution in 1:1 molar ratio gives the test of Fe^{2+} ion but $CuSO_4$ solution mixed with aqueous ammonia in 1 : 4 molar ratio does not give the test of Cu^{2+} ion. Explain why?

OR

(i) Using valence bond theory, explain the following in relation to the complexes given below :
$[Mn(CN)_6]^{3-}$, $[Co(NH_3)_6]^{3+}$, $[Cr(H_2O)_6]^{3+}$
(a) Type of hybridisation
(b) Inner or outer orbital complex
(c) Magnetic behaviour
(d) Spin only magnetic moment value

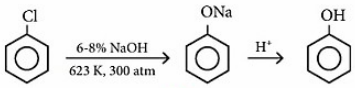
(ii) The colour of coordination compounds depends on the crystal field splitting. What will be the correct order of absorption of wavelength of light in the visible region, for the complexes, $[Co(NH_3)_6]^{3+}$, $[Co(CN)_6]^{3-}$ and $[Co(H_2O)_6]^{3+}$.

SOLUTIONS

1. (i)(d): Electron withdrawing group increases the reactivity towards nucleophilic substitution reaction. Hence, the order is II > III > I.

(ii) (a): The first step of the Dow process involves the abstraction of proton. Since the order of bond strength is: C— T > C — D > C — H.
Hence, the C—H bond can be easily broken. Therefore, (a) will be most reactive.

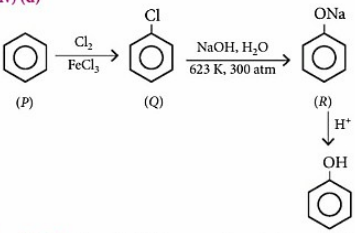
(iii) (b) : Dow's process is used for the preparation of phenols.



OR

(d) Dow's process involves nucleophilic substitution reaction.

(iv) (d)



2. (i) (d): Though HF has a greater electronegativity difference and more ionic character than the other hydrides, it is the weakest acid in water. The strength of an acid depends upon its degree of ionisation which, in turn, depends upon the bond strength. Higher the bond dissociation energy, lower is the degree of ionization and hence weaker is the acid. Since the bond dissociation energies of the hydrogen halides increases in the order ; HI < HBr < HCl < HF, therefore strength of the acids increases in the reverse direction *i.e.*, HF < HCl < HBr < HI. Another reason for low acidity of HF compared to other hydrogen halides is the strong H-bonding of F^-ion to H_3O^+ as compared to other halide ions.

(ii) (a): H_2SO_4 when react with NaBr and NaI, give out Br_2 and I_2 as concentrated H_2SO_4 is a strong oxidising agent.

(iii)(d) : Heat evolved in neutralisation of weak acid and strong base is less than 13.7 kcal because some heat is used up in ionisation of weak acid.

OR

(d) : Greater the bond dissociation energy, more stable is the hydrogen halide and hence weaker is the reducing agent. Therefore, reducing power of the hydrogen halides increases in the order :
HF < HCl < HBr < HI.

(iv) (b)

3. **(c)** : $P_{Total} = p^\circ_e x_e + p^\circ_m x_m$

where, $n_e = \frac{46}{46} = 1$, $n_m = \frac{16}{32} = 0.5$

$$x_e = \frac{1}{1.5} = \frac{2}{3},\ x_m = \frac{0.5}{1.5} = \frac{1}{3}$$

$$P_{Total} = 42 \times \frac{2}{3} + 88.5 \times \frac{1}{3} = 57.5$$

$$y_m = \frac{p_m}{P_{Total}}$$ ($\because$ y_m = mole fraction of methanol in vapour phase)

where, $p_m = p^\circ_m \cdot x_m = 88.5 \times \frac{1}{3} = 29.5$

$$y_m = \frac{29.5}{57.5} = 0.513$$

4. **(a)**

OR

(c) : 3° amines do not react with benzenesulphonyl chloride (Hinsberg's reagent) due to absence of hydrogen atoms attached to nitrogen atom.

5. **(a)** : P atoms are at the corners of the cube,

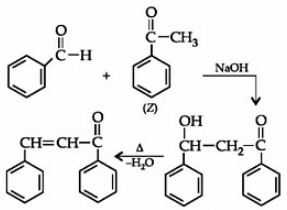
$\therefore$ Number of P atoms per unit cell = $\frac{1}{8} \times 8 = 1$

Q atoms are at the face centre of the cube,

$\therefore$ Number of Q atoms per unit cell = $\frac{1}{2} \times 6 = 3$

$\Rightarrow$ The formula of the molecule is PQ_3

6. **(d)** :



7. **(c)** : Degree of dissociation, $\alpha = \frac{\Lambda}{\Lambda^\circ}$

$\therefore$ $\alpha = \frac{15.8}{350} = 0.04514$

For monobasic acid, $HA \rightleftharpoons H^+ + A^-$

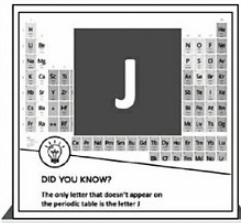
$$K = \frac{C\alpha^2}{(1-\alpha)} = C\alpha^2 \quad (\because \alpha <<< 1)$$

$\therefore$ $K = 0.05 \times (0.04514)^2$, $K = 1.019 \times 10^{-4}$

3 Amazing Facts You Must Know

Mars is red because of iron oxide

While Earth is sometimes referred to as the 'blue marble' because it's mostly covered with oceans and has a thick atmosphere, giving it a blue appearance. Mars is covered with a lot of iron oxide — these are the same compounds that give blood and rust their distinct color. In light of this, it's no coincidence that Mars, which occasionally appears as a bright red 'star', was named after the Greek god of war.



The only letter not appearing on the periodic table is J.

The letter "J" is the only one not found in the Periodic table. In some countries (e.g., Norway, Poland, Sweden, Serbia, Croatia), the element iodine is known by the name jod. However, the Periodic table still uses the IUPAC symbol I for the element iodine.

Did you know ... some lipstick contains lead acetate or sugar of lead? This toxic lead compound makes the lipstick taste sweet.

Have you noticed some lipsticks taste sweet on your lips even though when you read the ingredients list, they contain no sugar or other sweeteners, except the lead acetate. Lead acetate is found in red lipsticks more than other colors. The chemical helps with colorfastness, which is why it's also used as a color additive in "progressive" hair dye products.

OR

(c) : $E_{cell} = E°_{cell} - \frac{0.0591}{2} \log \frac{[Zn^{2+}]}{[Cu^{2+}]}$

From the given plot, $OA = E°_{cell} = 1.10$ V

$$1.1591 = 1.10 - \frac{0.0591}{2} \log \frac{[Zn^{2+}]}{[Cu^{2+}]}$$

$$\therefore \quad \log \frac{[Zn^{2+}]}{[Cu^{2+}]} = -2$$

Taking antilog $[Zn^{2+}]/[Cu^{2+}] = 0.01$

8. (d) : Oxidation state of

Ti in TiF_6^{2-} = + 4 *i.e.*, $Ti^{4+} \longrightarrow 3d^0$

Co in CoF_6^{3-} = + 3 *i.e.*, $Co^{3+} \longrightarrow 3d^6$

Ni in $NiCl_4^{2-}$ = + 2 *i.e.*, $Ni^{2+} \longrightarrow 3d^8$

Cu in Cu_2Cl_2 + 1 *i.e.*, $Cu^{+} \longrightarrow 3d^{10}$

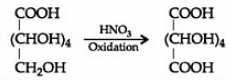
Colour of salts is a property of partially filled *d*-orbitals. Since TiF_6^{2-} has completely empty and Cu_2Cl_2 has completely filled *d*-subshells, hence, these are colourless salts.

9. (a) : Greater is the charge of cation, more effective is the coagulation of As_2S_3.

OR

(c)

10. (b) :



Gluconic acid — Saccharic acid

OR

(a)

11. (d) : Low value of $E°$ of V^{3+}/V^{2+} shows the stability of V^{2+} due to its half-filled t_{2g}^3 configuration.

12. (a)

13. (c) : For a first order reaction,

$$k = \frac{2.303}{t} \log \frac{a}{a - x}$$

$$k = \frac{2.303}{t_{1/2}} \log \frac{a}{a - a/2} = \frac{2.303}{t_{1/2}} \log \frac{a}{a/2} = \frac{2.303}{t_{1/2}} \log 2$$

Therefore, half-life period $t_{1/2} = \frac{2.303}{k} \log 2$

Thus, $t_{1/2}$ is independent of initial concentration of reactants for first order reaction.

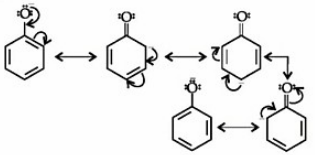
14. (d) : The correct order of 2nd *I.E.* is $_{23}V < {}_{24}Cr > {}_{25}Mn$. Cr after losing one electron has $3d^5$ half-filled stable configuration from which removal of second electron is difficult.

15. (c) : HCN is a weak acid and have low degree of dissociation but in presence of a base (even H_2O), the dissociation increases appreciably to provide appreciable CN^- to attack $\rangle C{=}O$ bond.

16. (a)

OR

(c) : Phenol is acidic in nature because phenoxide ion formed after ionisation is highly stable as the negative charge is delocalised due to resonance.



As phenoxide ion is highly stable it will act as weak base.

17. (b) Molar mass of CH_2Cl_2

$= 12 \times 1 + 1 \times 2 + 35.5 \times 2 = 85$ g mol^{-1}

Molar mass of $CHCl_3$

$= 12 \times 1 + 1 \times 1 + 35.5 \times 3 = 119.5$ g mol^{-1}

Moles of $CH_2Cl_2 = \frac{40 \text{ g}}{85 \text{ g mol}^{-1}} = 0.47$ mol

Moles of $CHCl_3 = \frac{25.5 \text{ g}}{119.5 \text{ g mol}^{-1}} = 0.213$ mol

Total number of moles = 0.47 + 0.213

= 0.683 mol

$$x_{CH_2Cl_2} = \frac{0.47}{0.683} = 0.688$$

$P_{total} = p_1° + (p_2° - p_1°)\, x_2$

$= 200 + (415 - 200) \times 0.688$

$= 200 + 147.9 = 347.9$ mm Hg

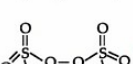
18. (i) *Refer to Answer 26(i), page no. 156 of MTG CBSE Champion Chemistry, Class 12.*

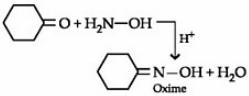
(ii) *Refer to Answer 17, page no. 156 of MTG CBSE Champion Chemistry, Class 12.*

OR

(i) As transition elements have a large number of unpaired electrons in the *d*-orbitals, they have strong interatomic attractions or metallic bonds. Hence, they have high enthalpy of atomisation.

(ii) Transition metals and their compounds, are known for their catalytic activity. This activity is ascribed to their ability to adopt multiple oxidation states, ability to adsorb the reactant(s) and ability to form complexes. Vanadium (V) oxide (in Contact process), finely divided iron (in Haber's process), and nickel (in catalytic hydrogenation) are some of the examples.

19. (i) 
(ii) 

20. (i) 

(ii) $CH_3COOH \xrightarrow{Cl_2/P} CH_2COOH$ (Cl)

21. For a first order reaction,

$$t = \frac{2.303}{k}\log\frac{[R]_0}{[R]}$$

$$t_{99.9\%} = \frac{2.303}{k}\log\frac{[R]_0}{\left([R]_0 - \frac{99.9}{100}[R]_0\right)}$$

$$= \frac{2.303}{k}\log\frac{[R]_0}{0.001[R]_0}$$

$$= \frac{2.303}{k}\log 1000 = \frac{2.303}{k}\times\log 10^3 = \frac{6.909}{k}$$

$$t_{1/2} = \frac{0.693}{k}$$

$$\Rightarrow \frac{t_{99.9\%}}{t_{1/2}} = \frac{6.909}{k}\times\frac{k}{0.693} = 10$$

OR

For a first order reaction,

$$t = \frac{2.303}{k}\log\frac{[R]_0}{[R]}$$

$$t_{99\%} = \frac{2.303}{k}\log\frac{[R]_0}{\left([R]_0 - \frac{99}{100}[R]_0\right)}$$

$$= \frac{2.303}{k}\log 100 = \frac{2.303\times 2}{k} = \frac{4.606}{k}$$

$$t_{90\%} = \frac{2.303}{k}\log\frac{[R]_0}{\left([R]_0 - \frac{90[R]_0}{100}\right)}$$

$$= \frac{2.303}{k}\log 10 = \frac{2.303}{k}\times 1$$

$$\frac{t_{99\%}}{t_{90\%}} = \frac{4.606}{k}\times\frac{k}{2.303} = 2 \Rightarrow t_{99\%} = 2t_{90\%}$$

22. (i) (a)  undergoes faster by S_N2 reaction.

(b)  is chiral.

(ii) (a) S_N2 reaction occurs with inversion of configuration.

(b) S_N1 reaction occurs with racemisation.

23. (i) Scattering of light by the colloidal particles takes place and the path of light becomes visible (Tyndall effect).

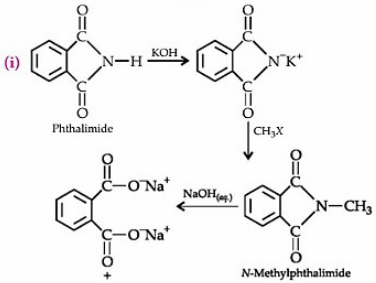
(ii) The positively charged colloidal particles of $Fe(OH)_3$ get coagulated by the oppositely charged Cl^- ions provided by NaCl.

24. Those amino acids which cannot be synthesised in the body and they must be obtained through diet are known as essential amino acids. *e.g.*, valine and lysine. The amino acids, which can be synthesised in the body are known as non-essential amino acids, *e.g.*, alanine and glutamic acid.

25. (i) *N*,*N*-Dimethylpropan-1-amine
(ii) 2-Methoxyaniline
(iii) Butan-1-amine **(iv)** Cyclohexanamine

OR

(i)



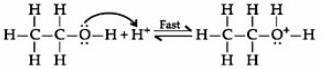
CH_3NH_2
Methylamine

(ii) $CH_3CH_2-\underset{\text{Propanamide}}{\overset{O}{\overset{\|}{C}}}-NH_2 + Br_2 + 4NaOH \longrightarrow$

$CH_3CH_2NH_2 + Na_2CO_3 + 2NaBr + 2H_2O$
Ethylamine

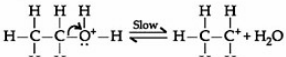
26. Mechanism

Step 1 : Formation of protonated alcohol :

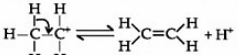


Step 2 : Formation of carbocation :

It is the slowest step and hence, the rate determining step of the reaction.



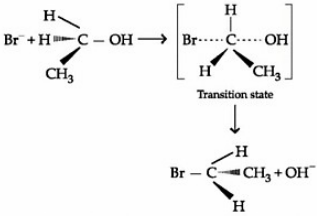
Step 3 : Formation of ethene by elimination of a proton.



The acid used in step 1 is released in step 3. To drive the equilibrium to the right, ethene is removed as it is formed.

OR

(i) The reaction proceeds through nucleophilic substitution bimolecular (S_N2) mechanism, as shown below :

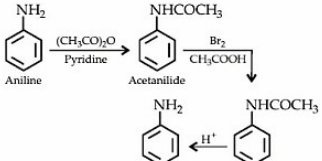


Inversion of configuration takes place during the reaction.

(ii) *Refer to Answer 28, page no. 215 of MTG CBSE Champion Chemistry, Class 12.*

27. *Refer to Answer 42, page no. 74 of MTG CBSE Champion Chemistry, Class 12.*

28. (i)



(ii) $C_2H_5NH_2 + HNO_2 \xrightarrow[H_2O]{NaNO_2/HCl} C_2H_5N_2^+Cl^-$
Ethanamine

$C_2H_5OH + N_2 + HCl \xleftarrow{H_2O}$
Ethanol

(iii) $CH_3NH_2 + CHCl_3 + 3KOH \xrightarrow{\text{Heat}}$
Methanamine

$CH_3NC + 3KCl + 3H_2O$
Methyl isocyanide

29. (i) Cu. This is because electronic configuration of Cu is $3d^{10}\ 4s^1$. After loss of one $4s$ electron, it acquires stable configuration of $3d^{10}$. Hence, removal of second electron is very difficult.

(ii) Zn. This is because electronic configuration of Zn is $3d^{10}4s^2$ and that of Zn^{2+} is $3d^{10}$ which is again fully filled and hence is very stable. Removal of third electron requires very high energy.

(iii) Zn. This is because it has completely filled $3d$ subshell and no unpaired electron is available for metallic bonding.

OR

(i) *Refer to Answer 28, page no. 156 of MTG CBSE Champion Chemistry, Class 12.*

(ii) Copper shows positive value of $E^{\circ}_{(Cu^{2+}/Cu)}$

Refer to Answer 42(i), page no. 157 of MTG CBSE Champion Chemistry, Class 12.

(iii) Mn is strong oxidising agent in +3 oxidation state because change of Mn^{3+} to Mn^{2+} give stable half filled (d^5) electronic configuration, $E^{\circ}_{(Mn^{3+}/Mn^{2+})} = 1.5$ V.

30. (i) For the *bcc* structure, nearest neighbour distance (d) is related to the edge (a) as $d = \frac{\sqrt{3}}{2}a$

or $a = \frac{2}{\sqrt{3}}d = \frac{2}{1.732} \times 365.9 = 422.5$ pm

For *bcc* structure, $Z = 2$

For sodium, $M = 23$

$$\therefore \quad \rho = \frac{Z \times M}{a^3 \times N_A}$$

$$= \frac{2 \times 23 \text{ g mol}^{-1}}{(422.5 \times 10^{-10} \text{ cm})^3 \times (6.02 \times 10^{23} \text{ mol}^{-1})}$$

$$= 1.013 \text{ g/cm}^3$$

(ii) The number of cation vacancies created in the lattice of NaCl is equal to the number of divalent Sr^{2+} ions added as one Sr^{2+} will replace two Na^+.

Conc. of $Sr^{2+} = 10^{-3}$ mol % $= \frac{10^{-3}}{100} = 10^{-5}$ mol

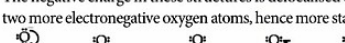
1 mole of $Sr^{2+} = 6.023 \times 10^{23}$ Sr^{2+} ions

10^{-5} mole of $Sr^{2+} = 6.023 \times 10^{23} \times 10^{-5}$

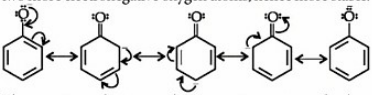
$= 6.023 \times 10^{18}$ Sr^{2+} ions

Hence, the concentration of cation vacancies is 6.023×10^{18}.

31. (i) (a)



The negative charge in these structures is delocalised over two more electronegative oxygen atoms, hence more stable.



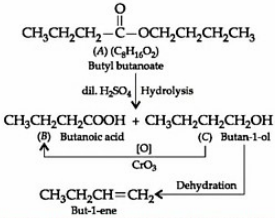
The negative charge in these structures is at the less electronegative carbon atom, hence less stable.

Therefore, carboxylic acid is stronger acid any than phenol.

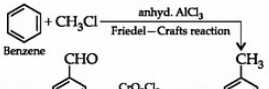
(b) $HCOOH > C_6H_5COOH > CH_3COOH$

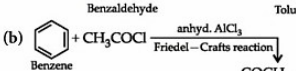
CH_3— group being electron releasing, decreases the acidity so, as formic acid does not contain any alkyl group, it is stronger acid. Phenyl group increases the acidity contrary to the decrease expected due to resonance effect.

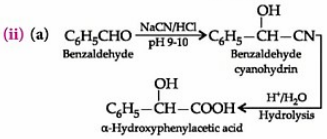
(ii) On hydrolysis with dilute sulphuric acid, (A) with $C_8H_{16}O_2$ molecular formula gives (B) and (C). (A) must be an ester. Since (C) on dehydration gives but-1-ene, so (C) must be an alcohol *i.e.*, butan-1-ol. Furthermore, oxidation of (C) with chromic acid produces (B), this means both acid (B) and alcohol (C) must have same number of carbon atoms.

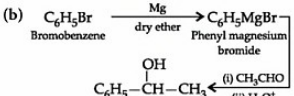


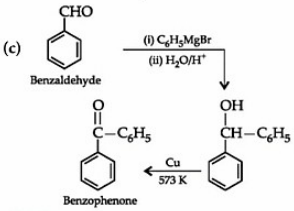
OR

(i) (a) 

(b) 

(ii) (a) 

(b) 

(c) 

32. (i) *Refer to Answer 63, page no. 57 of MTG CBSE Champion Chemistry, Class 12.*

(ii) *Refer to Answer 26, page no. 53 of MTG CBSE Champion Chemistry, Class 12.*

OR

The given reaction is

$$2Hg + 2Fe^{3+} \rightleftharpoons Hg_2^{2+} + 2Fe^{2+}$$

Initial concentration of $Fe^{3+} = 1.0 \times 10^{-3}$ M

Equilibrium concentration of $Fe^{3+} = 5\%$ of 1.0×10^{-3} M

$$= \frac{5}{100} \times 10^{-3} = 5 \times 10^{-5} \text{ M}$$

Equilibrium concentration of Fe^{2+}

$= (1.0 \times 10^{-3}) - (5 \times 10^{-5})$ M $= 0.95 \times 10^{-3}$ M

Equilibrium concentration of Hg_2^{2+}

$$= \text{half of the } Fe^{2+} \text{ ion} = \frac{0.95 \times 10^{-3}}{2} \text{ M}$$

We know that, $E_{cell} = E^\circ_{cell} - \frac{0.059}{n} \log \frac{[Hg_2^{2+}][Fe^{2+}]^2}{[Fe^{3+}]^2}$

But $E_{cell} = 0$ (Because reaction is at equilibrium)

$$\therefore \quad 0 = E^\circ_{cell} - \frac{0.059}{2} \log \frac{\left[\frac{0.95 \times 10^{-3}}{2}\right][0.95 \times 10^{-3}]^2}{[5 \times 10^{-5}]^2}$$

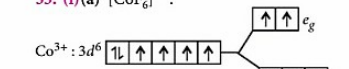
or $E^\circ_{cell} = -0.0226$

But $E^\circ_{cell} = E^\circ_{cathode} - E^\circ_{anode} = E^\circ_{Fe^{3+}/Fe^{2+}} - E^\circ_{Hg_2^{2+}/Hg}$

$-0.0226 = 0.77 - E^\circ_{Hg_2^{2+}/Hg}$

or $E^\circ_{Hg_2^{2+}/Hg} = 0.7926$ V

33. (i) (a) $[CoF_6]^{3-}$:



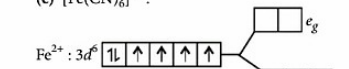
No. of unpaired electrons = 4, $\mu = \sqrt{4(4+2)} = 4.9$ B.M.

(b) $[FeF_6]^{3-}$:

No. of unpaired electrons = 5,

$\mu = \sqrt{5(5+2)} = 5.92$ B.M.

(c) $[Fe(CN)_6]^{4-}$:



No. of unpaired electrons = 0, $\mu = 0$

(ii) When $FeSO_4$ and $(NH_4)_2SO_4$ solutions are mixed in 1 : 1 molar ratio, Mohr's salt (a double salt) is formed.

$$FeSO_{4(aq)} + (NH_4)_2SO_{4(aq)} \rightarrow FeSO_4 \cdot (NH_4)_2SO_4 \cdot 6H_2O$$

$$FeSO_4 \cdot (NH_4)_2SO_4 \cdot 6H_2O \rightleftharpoons Fe^{2+}_{(aq)} + 2NH^+_{4(aq)} + 2SO^{2-}_{4(aq)} + 6H_2O_{(l)}$$

Because Fe^{2+} ions are formed on dissolution of Mohr's salt, its aqueous solution gives the test of Fe^{2+} ions.

When $CuSO_4$ is mixed with ammonia, following reaction occurs :

$$CuSO_{4(aq)} + 4NH_{3(aq)} \rightarrow [Cu(NH_3)_4]SO_4$$

This complex does not produce Cu^{2+} ion, so the solution of $CuSO_4$ and NH_3 does not give the test of Cu^{2+} ion.

OR

(i) $[Mn(CN)_6]^{3-}$:

$Mn^{3+}(3d^4)$:

	3d					4s		4p			
	↿⇂	↑	↑	×	×	×	×	×	×	×	

(a) Hybridisation - d^2sp^3

(b) Inner orbital complex **(c)** Paramagnetic

(d) $\mu = \sqrt{2(2+2)} = 2.83$ B.M.

$[Co(NH_3)_6]^{3+}$:

$Co^{3+}(3d^6)$:

	3d					4s		4p			
	↿⇂	↿⇂	↿⇂	×	×	×	×	×	×	×	

(a) Hybridisation - d^2sp^3

(b) Inner orbital complex

(c) Diamagnetic **(d)** $\mu = 0$

$[Cr(H_2O)_6]^{3+}$:

$Cr^{3+}(3d^3)$:

	3d					4s		4p			
	↑	↑	↑	×	×	×	×	×	×	×	

(a) Hybridisation - d^2sp^3 **(b)** Inner orbital complex

(c) Paramagnetic

(d) $\mu = \sqrt{3(3+2)} = 3.87$ B.M.

(ii) Strong field ligands split the five degenerate energy levels with more energy separation than weak field ligands, *i.e.,* as strength of ligand increases crystal field splitting energy increases. Hence, $\Delta E = \frac{hc}{\lambda}$

$\Rightarrow \Delta E \propto \frac{1}{\lambda} \Rightarrow \lambda \propto \frac{1}{\Delta E}$

As energy separation increases, the wavelength decreases. Thus, the correct order is

$[Co(H_2O)_6]^{3+} > [Co(NH_3)_6]^{3+} > [Co(CN)_6]^{3-}$

Scientist of the Month

Wilhelm Ostwald

Wilhelm Ostwald
(September 2, 1853 - April 4, 1932)

Friedrich Wilhelm Ostwald was a Baltic German chemist and philosopher. Ostwald is credited with being one of the founders of the field of physical chemistry.

Early Life and Academic Career

- Ostwald was born ethnically Baltic German in Riga, Russian Empire to master-cooper Gottfried Wilhelm Ostwald and Elisabeth Leuckel. Ostwald developed an interest in science as a child and conducted experiments at his home, particularly related to fireworks and photography.
- Ostwald began his career as an independent unpaid investigator at the University of Dorpat in 1875. He worked in the laboratory of Carl Schmidt. Ostwald completed his Magisterial degree at the University of Dorpat in 1877. Ostwald was deeply interested in questions of chemical affinity and the reactions that formed chemical compounds. Ostwald developed a three-dimensional affinity table that took into account the effects of temperature as well as the affinity constants of acids and bases. Ostwald also investigated mass action, electrochemistry and chemical dynamics. Ostwald published his doctoral dissertation at the University of Dorpat in 1878, with Carl Schmidt as his thesis advisor.
- In 1881, Ostwald became a Professor of Chemistry at the Riga Polytechnicum. In 1887, he moved to Leipzig University where he became Professor of Physical Chemistry. Ostwald remained on the faculty at Leipzig University until his retirement in 1906. He also served as the first "exchange professor" at Harvard University in 1904 and 1905. Following his 1906 retirement, Ostwald became active in philosophy, politics, and other humanities.
- During the course of his academic career, Ostwald published more than 500 original research papers for the scientific literature and approximately 45 books.

Scientific Contributions

- Ostwald invented a process for the inexpensive manufacture of nitric acid by oxidation of ammonia. Ostwald also conducted significant research on dilution theory leading to his conceptualization of the law of dilution which at times is referred to as "Ostwald's Dilution Law". Ostwald articulated the idea that a catalyst is a substance that accelerates the rate of a chemical reaction without being a part of either the reactants or the products.
- Ostwald studied the crystallization behavior of solids. He discovered that solids do not necessarily crystallize in their most thermodynamically stable form but instead sometimes crystallize preferentially in other forms dependent on the relative rates of crystallization of each polymorphic form. In 1906, Ostwald was elected a member of the International Committee on Atomic Weights.

Honours and Awards

- In 1909, Ostwald received Nobel Prize for Chemistry for his contributions to understanding catalysis and for his investigations of the fundamental principles underlying chemical equilibria and reaction rates. He was nominated for the Nobel Prize 20 times beginning in 1914. In 1923, Ostwald was awarded the Wilhelm Exner Medal, which recognized the economic impact of Ostwald's scientific contributions.
- In 1904, he was elected a foreign member of the Royal Netherlands Academy of Arts and Sciences. He became an honorary member of scientific societies in Germany, Sweden, Norway, Netherlands, Russia, Great Britain, and the United States. Ostwald received honorary doctorates from various universities in Germany, Great Britain and the United States. In 1899, he was made a Geheimrat by the King of Saxony, which by that time was a recognition of Ostwald's scholarly contributions. Wilhelm Ostwald Park and Museum in Grimma, Germany, at the site of Ostwald's vacation home. This institution also houses many of Ostwald's scholarly works.
- Ostwald crater, which is on the far side of the Earth's moon, was named in honor of Wilhelm Ostwald.

MONTHLY TEST DRIVE

This specially designed column enables students to self analyse their extent of understanding of specified chapters. Give yourself four marks for correct answer and deduct one mark for wrong answer. Self check table given at the end will help you to check your readiness.

Total Marks : 120 **The *d*- and *f*-Block Elements | Coordination Compounds** **Time Taken : 60 Min.**

NEET

Only One Option Correct Type

1. The pair in which both species have same magnetic moment (spin only value) is
   (a) $[Cr(H_2O)_6]^{2+}$, $[CoCl_4]^{2-}$
   (b) $[Cr(H_2O)_6]^{2+}$, $[Fe(H_2O)_6]^{2+}$
   (c) $[Mn(H_2O)_6]^{2+}$, $[Cr(H_2O)_6]^{2+}$
   (d) $[CoCl_4]^{2-}$, $[Fe(H_2O)_6]^{2+}$

2. When MnO_2 is fused with KOH, a coloured compound is formed, the product and its colour is
   (a) K_2MnO_4, purple-green
   (b) $KMnO_4$, purple
   (c) Mn_2O_3, brown
   (d) Mn_3O_4, black.

3. Which of the following cations gives blood red colour with ammonium thiocyanate?
   (a) Fe^{3+} (b) Fe^{2+} (c) Cu^{2+} (d) Cd^{2+}

4. Arrange Ce^{3+}, La^{3+}, Pm^{3+} and Yb^{3+} in increasing order of their ionic radii.
   (a) $Yb^{3+} < Pm^{3+} < Ce^{3+} < La^{3+}$
   (b) $Ce^{3+} < Yb^{3+} < Pm^{3+} < La^{3+}$
   (c) $Yb^{3+} < Pm^{3+} < La^{3+} < Ce^{3+}$
   (d) $Pm^{3+} < La^{3+} < Ce^{3+} < Yb^{3+}$

5. Which is not true about the coordination compound $[Co(en)_2Cl_2]Cl$?
   (a) It exhibits geometrical isomerism.
   (b) It exhibits optical isomerism.
   (c) It exhibits ionization isomerism.
   (d) It is an octahedral complex.

6. Potassium permanganate acts as an oxidant in alkaline and acidic medium. The final products formed from $KMnO_4$ in the two conditions are respectively
   (a) MnO^{2-} and Mn^{3+} (b) Mn^{3+} and Mn^{2+}
   (c) Mn^{2+} and Mn^{3+} (d) MnO_2 and Mn^{2+}.

7. The hybridisation of atomic orbitals of the transition metals in the following complexes are respectively $[Fe(H_2O)_6]^{3+}$, $[Co(NH_3)_6]^{3+}$, $[Ni(CN)_4]^{2-}$, $[Ni(CO)_4]$
   (a) d^2sp^3, sp^3d^2, dsp^2, sp^3
   (b) sp^3d^2, d^2sp^3, sp^3, dsp^2
   (c) sp^3d^2, d^2sp^3, dsp^2, sp^3
   (d) d^2sp^3, sp^3d^2, sp^3, dsp^2

8. The geometry of $[Ni(CO)_4]$ and $[Ni(PPh_3)_2Cl_2]$ is
   (a) square planar for both
   (b) tetrahedral and square planar respectively
   (c) tetrahedral for both
   (d) square planar and tetrahedral respectively.

9. Oxygen is not evolved when conc. H_2SO_4 reacts with
   (a) $KMnO_4$ (b) MnO_2
   (c) $K_2Cr_2O_7$ (d) $CuSO_4$

10. $CuSO_4$ reacts with KCN solution and forms
    (a) $K_3[Cu(CN)_4]$ (b) CuCN
    (c) $Cu(CN)_2$ (d) $K_4[Cu(CN)_6]$

11. Amongst the following, the most stable complex is
    (a) $[Fe(H_2O)_6]^{3+}$ (b) $[Fe(NH_3)_6]^{3+}$
    (c) $[Fe(C_2O_4)_3]^{3-}$ (d) $[FeCl_6]^{3-}$

12. Which of the following complexes will give maximum number of isomers?
(a) $[Co(NH_3)_4Cl_2]$ (b) $[Ni(en)(NH_3)_4]^{2+}$
(c) $[Ni(C_2O_4)(en)_2]^{2-}$ (d) $[Cr(SCN)_2(NH_3)_4]^{+}$

Assertion & Reason Type

Directions : In the following questions, a statement of assertion is followed by a statement of reason. Mark the correct choice as :
(a) If both assertion and reason are true and reason is the correct explanation of assertion.
(b) If both assertion and reason are true but reason is not the correct explanation of assertion.
(c) If assertion is true but reason is false.
(d) If both assertion and reason are false.

13. **Assertion :** Cuprous ion (Cu^+) is colourless whereas cupric ion (Cu^{2+}) is blue in the aqueous solution.
Reason : Cuprous ion (Cu^+) has unpaired electrons while cupric ion (Cu^{2+}) does not have.

14. **Assertion :** Lanthanoids show a limited number of oxidation states whereas actinoids show a large number of oxidation states.
Reason : Energy gap between 4*f*, 5*d* and 6*s* sub-shells is small whereas that between 5*f*, 6*d* and 7*s* sub-shells is large.

15. **Assertion :** Complexes $K_4[Fe(CN)_6]$ and $[Co(NH_3)_5(CO_3)]Cl$ do not show geometrical isomerism.
Reason : Geometrical isomerism is not shown by complex $[Pt(NH_3)(Cl)(py)(Br)]$.

JEE MAIN / JEE ADVANCED

Only One Option Correct Type

16. The donor atoms in EDTA are
(a) two N and two O (b) two N and four O
(c) four N and two O (d) three N and three O.

17. The colourless species is
(a) VCl_3 (b) $VOSO_4$
(c) Na_3VO_4 (d) $[V(H_2O)_6]SO_4 \cdot H_2O$

18. Which of the following ions are colourless?
Ti^{3+}, Sc^{3+}, Ag^+, Cd^{2+}, Cu^{2+}
I II III IV V
(a) Only I and V (b) Only II, III and IV
(c) Only I, III and V (d) Only III and IV

19. Correct name of the following complex is $[Cr(H_2O)_4Cl_2]NO_3$
(a) dichloridotetraaquachromium (III) nitrate
(b) tetraaquadichloridochromium (III) nitrate
(c) tetraaquadichloridochromium (IV) nitrito
(d) dichloridotetraaquachromium (IV) nitrito.

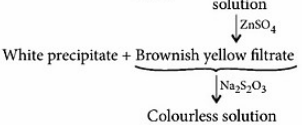
More than One Options Correct Type

20. Which of the following ions show higher spin only magnetic moment values?
(a) Ti^{3+} (b) Mn^{2+} (c) Fe^{2+} (d) Co^{2+}

21. Metal *M* forms a coloured complex with ligand *A* and colourless complex with ligand *B*, which has a low dissociation constant than that of *M* with *A*. Concentration of *M* ion can be estimated by
(a) using *A* as titrant and *B* as an indicator
(b) the end point which corresponds to just appearance of colour
(c) using *B* as titrant and *A* as an indicator
(d) the end point which corresponds to just disappearance of colour.

COMIC CAPSULE

22. For the given aqueous reactions, which of the following statements are true?



(a) The first reaction is a redox reaction.
(b) White precipitate is $Zn_3[Fe(CN)_6]_2$.
(c) Addition of filtrate to starch solution gives blue colour.
(d) White precipitate is soluble in NaOH solution.

23. Which of the following statements are correct about Wilkinson's catalyst?
(a) It is used as a homogeneous catalyst for selective hydrogenation of organic molecules at room temperature and pressure.
(b) It is a tetrahedral complex.
(c) It does not have unpaired electrons.
(d) Its formula is $TiCl_4 + Al(C_2H_5)_3$.

Integer / Numerical Value Type

24. The coordination number of the element *M* in the complex $M(DMG)_2$ (where *DMG* is dimethylglyoxime) is

25. The coefficient of H_2S on balancing the equation is
$K_2Cr_2O_7 + H_2SO_4 + H_2S \longrightarrow K_2SO_4 + Cr_2(SO_4)_3 + H_2O + S$

26. The number of unpaired electrons in square planar complex of Co^{2+} is

Comprehension Type

A certain metal (*A*) is boiled in dilute nitric acid to give a salt (*B*) and an oxide of nitrogen (*C*). An aqueous solution of (*B*) with brine gives a precipitate (*D*) which is soluble in NH_4OH. On adding the aqueous solution of (*B*) to hypo solution, a white precipitate (*E*) is obtained. (*E*) turns black on standing.

27. Metal (*A*) is
(a) Na (b) Be (c) Mg (d) Ag

28. A white precipitate (*E*) is
(a) $Na_2S_2O_3$ (b) $Ag_2S_2O_3$
(c) MgS_2O_3 (d) $K_2S_2O_3$

Matrix Match Type

29. Match the entries listed in Column I with appropriate entries listed in Column II.

Column I	Column II
(A) K_2MnO_4	(P) Transition element in +6 state
(B) $KMnO_4$	(Q) Oxidising agent in acidic medium
(C) $K_2Cr_2O_7$	(R) Manufactured from pyrolusite ore
(D) K_2CrO_4	(S) Manufactured from chromite ore

	A	B	C	D
(a)	P,Q	P,S	Q,R	P,R
(b)	P,R	Q,R	P,Q,S	P,Q,S
(c)	P,R,Q	Q	S,R	R
(d)	Q,R,S	R,S	P,Q	Q,R

30. Match the complexes in Column I with their properties listed in Column II.

Column I	Column II
(A) $[Co(NH_3)_4(H_2O)_2]Cl_2$	(P) Geometrical isomers
(B) $[Pt(NH_3)_2Cl_2]$	(Q) Paramagnetic
(C) $[Co(H_2O)_5Cl]Cl$	(R) Diamagnetic
(D) $[Ni(H_2O)_6]Cl_2$	(S) Metal ion with +2 oxidation state

	A	B	C	D
(a)	Q,S	R,P	R,S	P,S
(b)	P,Q,S	Q,S	P,R,S	Q,S
(c)	P,R,S	S,R	P,S	P,Q
(d)	P,Q,S	P,R,S	Q,S	Q,S

◈◈

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SELF CHECK

No. of questions attempted .....
No. of questions correct .....
Marks scored in percentage .....

Check your score! If your score is

> 90%	EXCELLENT WORK !	You are well prepared to take the challenge of final exam.
90-75%	GOOD WORK !	You can score good in the final exam.
74-60%	SATISFACTORY !	You need to score more next time.
< 60%	NOT SATISFACTORY!	Revise thoroughly and strengthen your concepts.

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